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This compilation of readings in educational media and research makes accessible published and unpublished documents relevant to designers and users of educational media. Volume II includes part 3, "Research on Media Types," part 4, "Media Design and Production," and part 5, "Media Content and Objectives." "Research on Media Types" includes summaries of research and selected studies on instructional television, compressed speech, textbook design, pictorial illustration for use in underdeveloped countries, and graphic presentation. "Media Design and Production" translates theory and research into an instructional product, considering visuals, scientific knowledge of psychology, theories of information transmission to media design, and significant film production variables. "Media Content and Objectives" suggests a framework for studying the variables contributing to media effects and offers guidelines for selecting and developing particular types of media to accomplish specific instructional objectives, summarizing the research pertaining to the accomplishment of different educational objectives. The relationship of media to the learning of concepts is also treated. Extensive bibliographies follow these papers. (MM)

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(Volume II)

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PART THREE

RESEARCH ON MEDIA TYPES

INSTRUCTIONAL TELEVISION

by Leslie P. Greenhill

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Educational historians of the future will probably note that the period from 1945 to 1965 represented two decades of intensive research on the development and use of films and television as instructional media, that is to say, as media for the stimulation of learning in more or less formal classroom situations. These historians may also note that this research was stimulated largely by a rapidly growing population that needed to be educated, by a predicted and actual shortage of competent teachers, and by the need for students to learn more than ever before because of the explosion of human knowledge during this period.

The great volume of research on these media has been made possible largely by considerable financial support, first from the Defense departments in the late 1940's and the 1950's; then by several of the philanthropic foundations in the mid-1950's; and more recently by the federal government through such agencies as the Office of Education. Alongside well-financed programs of research and well-supported projects there has been a steady stream of dissertation research conducted by individual researchers, sometimes under the auspices of well-financed programs, and often on the "shoestring" support that often characterizes doctoral studies.

Objectives of this Review

In 1951, under the auspices of the Instructional Film Research Program at The Pennsylvania State University, and with the financial support of the U.S. Naval Training Devices Center, Hoban and Van Ormer (5) produced a comprehensive report which summarized the results of over 200 experiments on instructional films conducted between 1918 and 1950.

Reprinted from "A Review of Some Trends in Research on Instructional Films and Instructional Television" by Leslie P. Greenhill. In Abstracts of Research on Instructional Television and Film: An Annotated Bibliography by Donald W. MacLennan, J. Christopher Reid. The material was prepared for the Institute of Communication Research, Stanford University, under a contract with the U.S. Office of Education, authorized under Title VII-B of the National Defense Education Act of 1958.

Practically all of the studies of television for instructional uses have been conducted since 1950. In fact, the decade from 1954-1964 might be characterized as the era of most intensive research on instructional television.

The purpose of this introductory review is not to summarize individual studies; rather it is to point out (1) the directions in which the research has been going, (2) the present status of the research, and (3) some possible future directions for research on instructional films and instructional television.

In meeting these objectives an attempt will be made to indicate what is known with some confidence, that might be useful to school and college administrators and to film or television production personnel. In addition, some problems and possibilities in methodology will be discussed which may be helpful to graduate students and other researchers.

Categories of Research

In studying the accompanying abstracts, certain categories of studies became apparent to the writer, and it is proposed to discuss the trends of research within these categories. They are:

1. Comparisons of televised with direct or face-to-face instruction.

2. Comparisons of filmed or kinescoped courses with direct instruction.

3. Studies of other uses of television for instruction.

4. Studies of other applications of films for instruction.

5. Studies of attitudes related to instructional television.

6. Studies of attitudes related to instructional films.

7. Studies of effects of production variables in instructional television programs.

8. Studies of effects of production variables in films.

Comparisons of Televised Instruction with Direct Instruction

By far the largest category of research is that of "relative effectiveness" studies in which the performance of students instructed over television has been compared with the performance of others instructed directly or face-to-face by a teacher in the usual way. This therefore represents perhaps the most important trend of research in the last decade.

These relative effectiveness studies range from elementary school to college levels of instruction and to military training. They encompass a very wide scope of subject matter, for example: elementary school reading, foreign language speech and listening skills, physical sciences, social sciences, biological sciences, mathematics, and such military subjects as basic training and electronics.

The length of the studies varies from one or a few lessons to entire courses extending over a semester or a year. One military study involved a comparison of the performance of students who viewed television approximately eight hours a day for a period of a week, with that of trainees who received a similar amount of direct classroom instruction.

The vast majority of these studies has revealed "no significant differences" in measured performance between students who were instructed over television and those who were taught directly. A few studies have shown differences in favor of television, while a few others have found differences in the opposite direction. In some instances differences were found on immediate tests of learning which disappeared when students were retested after a delay of a few days or weeks.

Problems of Experimental Design

It must be said that a number of the studies are very uneven in quality, which makes interpretation of the results difficult or impossible. For example, in many studies the main variable (TV versus direct instruction) is mixed in with other variables such as different teachers teaching under each of the conditions. In this situation the comparison is really between Teacher A teaching on television assisted by Teachers B, C, D, etc., in follow-up work; with Teachers E, F, G, H, etc., in regular classroom situations. As a result of the varying experience and competence of the teachers in the various treatments, the results may favor one "method" or the other.

Another serious deficiency in some of the studies is the use of existing or intact classes (often in different schools) in the different comparison groups. This situation is often dictated by administrative convenience or by ignorance of the fact that such a situation makes comparisons between methods of instruction virtually uninterpretable. To be sure, in many of these studies efforts were made to measure initial differences between classes on some variable or variables expected to influence the results of the comparisons, such as intelligence, previous experience, number of members of each sex in the groups, and so forth, and then students were either "matched" across the methods being used or some statistical technique was employed in an endeavor to compensate for differences which existed between the groups whose performance was to be compared.

These efforts to compensate for inadequacies in experimental design are themselves inadequate in many instances, because other unrecognized variables may be operating to bias the results. Some examples of such uncontrolled variables might be: differences between schools in socio-economic status of students (i.e., some schools draw children from homes with richer environments than others). While the children may appear to be equal in previous knowledge, one group may have more potential for learning than the other or may get more help at home. A second kind of uncontrolled variable might be differences in motivation which result from differences in morale in various classes or schools.

The foregoing are cited merely as examples of factors that could bias the outcomes of comparisons. There may be many others. The only satisfactory way to deal with such variables is randomly to assign students to the comparison groups in such a way that uncontrollable biasing variables of the kind mentioned have an equal chance of affecting both groups. The results of experimental comparisons involving such randomized groups can then be interpreted using probability theory and appropriate tests of significance.

The reason for making such a strong issue of this matter here is in the hope that educational administrators will do everything possible to provide adequate conditions for experiments to be conducted that will have interpretable results and valid outcomes!

Stickell (9), in a study conducted in 1963, carefully examined some 250 studies which had compared televised instruction with direct instruction. These were classified according to the extent to which they met his rather rigorous requirements for adequate experimental designs. Of the 250 comparisons, 217 were classified as "uninterpretable," 23 were classified as "partially interpretable," because of various defects in experimental design, and only 10 of the studies were classified as "interpretable." Of these 10, all showed no significant differences in learning at the .05 level between televised and direct instruction.

In summing up the results of the preceding discussion, it seems to the writer that the finding of "no significant differences" in comparisons of measured learning from direct and televised instruction is the only outcome from the "comparative effectiveness" studies in which there can be a good deal of confidence.

The Significance of Nonsignificant Differences

Many administrators and researchers have expressed disappointment at the frequency with which nonsignificant differences in learning have resulted from comparisons of direct and televised instruction and they seem to regard this finding as a negative result.

Later in the section on possible lines for future research there will be a discussion on some of the reasons why nonsignificant differences seem to typify the results of this kind of research. While a finding of no significant differences does not prove that no differences exist, there is a practical value in such results in that consistent findings of nonsignificant differences in learning from different instructional methods give educational administrators some confidence that several alternative methods of instruction are available for use, and the choice of which should be used in a specific situation may be based on considerations other than relative effects of the methods on learning.

For example, television has excellent distributive powers. It can extend instruction (good or bad) to many places simultaneously. It is, therefore, an excellent means of extending experienced teachers and above-average teaching resources to larger numbers of students than would be possible under conditions of direct instruction. In this way television can be used to offset a shortage of experienced teachers. To the extent that the television teacher is more experienced than the available classroom teachers and has better instructional resources than might be available to the average classroom teacher, it is possible that televised instruction can be superior to direct teaching. Some of the findings favoring televised instruction can possibly be accounted for by differences in the abilities of the teachers in the comparison situations rather than by the influence of television *per se*.

Another reason for using television may be to offer courses that would otherwise be unavailable. In some cases there may also be economic advantages from the use of televised instruction.

It is for these reasons that the use of instructional television has expanded so rapidly during the past ten years.

Comparisons of Filmed or Kinescoped Courses with Direct Instruction

A relatively small number of studies has been concerned with comparisons of learning from filmed courses, sometimes supplemented by a local teacher, with direct instruction. Some of the filmed courses have been originally produced as films; others were originally produced as television programs and made available for classroom use in the form of kinescope recordings.

A study by VanderMeer (10) in 1949 compared learning of groups of students in a ninth-grade biology course who were taught by (a) 44 sound films alone (each film was seen twice), (b) the same films plus specially prepared study guides, and (c) standard lecture-demonstration-discussion methods by a classroom teacher. There were no significant differences in performance of the students among the three methods on either immediate tests or delayed recall after three months. However, the "films only" group took about 20 percent less time than the other two treatment groups to complete the course.

This general pattern of no significant differences has characterized more recent studies that have compared filmed courses with direct instruction in such subject areas as college-level psychology and communication skills, high school chemistry, physics, history, and industrial arts, and some technical subjects in military training. These studies indicate the potential usefulness of such film series as those being produced under the auspices of the Physical Sciences Study Committee and the Biological Sciences Curriculum Study Committee.

In individual situations it might be desirable to conduct quality control experiments to determine whether the use of such film series has advantages over the existing classroom situation. However, in many high schools and colleges where great difficulty is being experienced in securing qualified faculty in certain specialized subjects, there is little doubt that effective learning can be stimulated by using such film series, or series of videotapes produced by other institutions, supplemented by whatever local resources are available.

A large area for future development and experimentation is the filmed course for home study using the recently introduced cartridge-loading 8mm film projectors. Such courses may prove to be very satisfactory for the retraining of adults, especially in technical and professional fields.

Studies of Other Uses of Television for Instruction

While the dominant trend in instructional television studies over the past ten years has centered around comparisons of televised with direct instruction, there has also been a fairly steady stream of research which is concerned with developing uses for television other than the presentation of substantial parts of courses, and in exploring for ways of more effectively using television for classroom instruction.

Observation of Demonstration Teaching

Because of the difficulties of taking increasingly large numbers of teacher trainees into classrooms to observe demonstration lessons, a number of studies have been directed toward comparisons of televised observation of teaching situations with actual classroom visitations. One of the main difficulties faced by such studies is the selection or development of appropriate criteria for evaluating the effectiveness of the methods being compared. In some instances, where the observations have been part of a required course on methods of teaching, the course examinations have been used as the criteria. In such cases there may be very few questions on which observation of teaching demonstrations has a direct bearing. In several other studies, strong efforts have been made to determine the unique contributions to the learning of student teachers which should be derived from such observations, and special situational tests covering classroom behavior of teachers have been developed to assess the effects of such observations. Some studies have been concerned also with students' preferences for one method of observation or another.

The generalizations that can be offered at the moment indicate that teacher trainees appear to gain as much from televised observations as from actual visitations; that they tend to prefer direct observation and, where televised observations are used, two or more views of the classroom being observed are preferred over one view. In many situations it has been found possible to install two or three television cameras, one of which provides a general scene of the classroom being observed, while the others provide close-ups, and all two or three scenes can be viewed simultaneously on adjacent television receivers by the student teachers. This method of observing teaching demonstrations has several practical advantages: (1) It permits observations by larger numbers of students than could be handled in classroom visitations. (2) Concurrent analysis and discussion can be conducted. (3) The viewing can be at a convenient location remote from the demonstration classroom.

The major technical problem appears to be in the pick-up of classroom conversations by microphones. This problem is being solved in various ways, through the use of acoustical treatment of the classroom including a rug on the floor, by multiple microphones, and, if necessary, by use of a roving microphone handled by the demonstrating teacher, whose own voice can be conveniently heard by means of a lavalier microphone on a long cord or by a wireless microphone.

Another use of television for teacher training that is just beginning to be studied and that deserves more study and evaluation is the recording (or even experienced teachers) and the subsequent analysis and discussion of these performances by the teacher concerned and by others who may be able to assist in the improvement of such classroom performances. Before-and-after videotape recordings could be compared in effectiveness under controlled conditions in order to determine whether changed classroom behavior on the part of a teacher actually produced more learning by the students.

In-service Training and Professional Training

Another observable trend in the research of the past few years is the use of television for in-service training of teachers and other professional personnel. Some of the studies in the accompanying abstracts indicate that such objectives can be effectively attained.

With the rapidly growing need for retraining in many professions as a result of new developments and the need to train people for new jobs as the result of technological changes in the nation's economy, it would appear that much more research along these lines is going to be needed if effective procedures are to be developed to help individuals avoid professional obsolescence. The use of television or films may be the only practical way of carrying such training to the numbers of people who need it.

Television for Teaching Performance Skills

Another line of research is developing out of a few studies of the use of television for teaching performance skills (technically known as perceptual motor skills). Much more research on teaching such skills was done with films in the early 1950's, probably because of the interest of the military sponsors of film research in improving the performance skills of military trainees. However, the flexibility and reach of television make it a potentially excellent medium for the teaching of a wide variety of perceptual motor skills. In the accompanying abstracts there are a few studies that have dealt with the teaching of typewriting, elementary-level reading, and the development of laboratory skills in the sciences.

Many possibilities for future exploration and study suggest themselves in the development of reading proficiency in high school children and adults, the teaching of trouble shooting for repair men, the teaching of assembly skills, even the teaching of improved driving habits for car owners!

In teaching some skills it is undoubtedly necessary to provide for concurrent practice by the learner. To achieve this, a demonstration is presented in a series of steps and time is allowed for the learners to perform each step on their equipment before the next step is shown over television. Some of the early film research studies testified to the efficiency of this method if the rate of development of the presentations was slow enough to permit the learners to alternate attention between the demonstration on film and their own performance.

In teaching certain kinds of skills at the elementary school level (e.g., foreign language) it has been found advantageous to elicit the help of parents by having them view the broadcasts and then provide an extension of the learning situation at home. Such a procedure might well be used for assisting preschool children to acquire reading skills, by teaching their parents the basic requirements for developmental reading.

Supplementary Activities

There has been an increasing number of research studies which have investigated various means of supplementing televised instruction. These have included the use of workbooks or study guides, correspondence materials, programed materials, and discussions led either by qualified teachers or by advanced students.

Whether or not these supplements lead to increased learning seems to depend on whether they are in addition to the full television lesson or lessons, thus requiring increased time, or whether they are substituted for part of the lesson. In the former case, the studies tend to show increases in learning, to the extent that the supplementary activities are relevant to what is being tested and if they reinforce or clarify what was presented in the television lessons. If the supplementary activities are substituted for part of the television lesson, it does not seem to matter very much which combination is used. There is little doubt, though, that repetition in some form or another is one of the most effective ways of increasing learning. In the practical classroom situation such repetition may result from supplementing televised instruction with discussion, projects, homework assignments, reading, laboratory work, and the like.

Another continuing line of research has been concerned with viewing conditions in television classrooms. Some studies have been concerned with such variables as size of the viewing groups, screen viewing angle and distance, and small-screen versus large-screen television. In most of these studies, within broad limits, it has been found that these variables do not relate significantly to learning. Obviously the learners have to be able to see the stimulus materials, read printed symbols presented over television, and hear what is carried by the audio. In most television classroom situations this is possible, although poor acoustics, or excessive light from outside or within the room may operate to reduce the clarity of picture and sound cues.

For practical production reasons it is generally desirable to set some standards for maximum viewing distance, and then in selecting size of print and amount of material to be covered by the television camera the producer should ensure that such material will be legible when viewed by learners with normal eyesight from the maximum viewing distance. A commonly used standard for maximum viewing distance is twelve times the width of a television screen and for viewing angle not more than 45° on either side of a line perpendicular to the face of the screen.

One aspect of the learning environment which has not been systematically studied is the physical climate--temperature, humidity, and air circulation. Many television classrooms and rooms used for film projection have very poor ventilation, and this condition may interfere with learning.

Studies of Other Applications of Films for Instruction

In recent years the research on the use of films for serving a variety of educational purposes has closely paralleled the research on television. This is not exactly surprising, because some film studies have actually used kinescope recordings produced from television programs. In fact, it is often difficult to decide whether a specific study is television research or film research.

Films, however, do have some special characteristics. It is usually easier to record a wide range of stimulus materials on films from many different locations and in this way to being the outside world into the classroom. Furthermore, while television may afford an excellent way of distributing films to classrooms, there are many classrooms that do not have access to television. In addition, some new ways have recently been developed for packaging and using instructional films that encourage new applications. Because of these possibilities there have been some differences in research on the use of films and television for some instructional purposes that should be noted:

Observation of Demonstration Teaching

Several studies have used documentary films of actual classroom teaching for teacher-training purposes. This has permitted a wider sampling of teaching demonstrations than would ordinarily be possible with live televised observations or classroom visitations. The films can be reviewed several times if desired.

Similarly, films of student-teaching performance have been made and used to assist the training of student teachers. Some of these studies have shown significant differences in favor of the film groups in comparison with those submitted to traditional procedures.

Films for Teaching Skills

There have been some studies in the past 10 to 15 years in which films have been used for teaching performance skills such as reading, typing, sewing, athletic skills, and foreign language vocabulary.

As was indicated in a previous section, much more of this research is needed, as many new applications for films have been opened up by the development of special projectors and easy-to-load cartridges containing 8mm film loops. This equipment provides excellent opportunities for establishing self-instructional situations, especially for teaching laboratory, language, and reading skills.

The use of this equipment is at present in what might be described as a developmental phase. Soon it should be ready for some serious research.

Studies conducted in recent years in the methods of using films provide further evidence of the effectiveness of repetition as a means of increasing learning. However, several studies have shown that even this variable can be used to excess, and that it is possible to produce a reduction in learning as well as negative attitudes by too many showings of a film (usually in excess of two or three showings).

There is some evidence that practice in learning from a given medium results in the development of an ability to learn from that medium with increasing effectiveness.

Feedback

There have been efforts to provide various methods of feedback to the instructor and/or learner in learning situations where extensive use is being made of television or films.

Some studies have involved the use of two-way communication systems in conjunction with closed-circuit television. Others have included the presentation of questions at the end of a television program or film showing--with provision of correct answers to the learners, and knowledge of level of performance to the teacher who can then supplement the material provided by the film or television lesson.

Immediate knowledge of results on tests appears to increase learning, but there are not enough studies of the use of electronic feedback and classroom communicator systems to be able to note any consistent trends in results.

It is suggested, however, that for such feedback systems to be effective, every student must respond to questions, respond to them frequently, and receive immediate knowledge of results. An alternative way of providing for such interaction between learners and stimulus materials is to program questions and knowledge of results into the filmed or televised lessons themselves. Some studies of these possibilities will be discussed in a later section.

Realistic Performance Tests

An application of films and television which has been the subject of very little research is the use of these media for the presentation of likelike performance tests. Such test situations can contain most of the visual and sound stimuli found in real life and can test performance beyond that which paper-pencil tests can cover.

Because they present concrete situations, such tests can avoid the ambiguities of meaning sometimes present in verbal tests, and this can result in high reliability.

Studies of Attitudes Related to Instructional Television

Attitudes of Students and Faculty

Research on instructional television has placed heavy emphasis on assessing the attitudes of students and teachers to the use of television for the presentation of classroom instruction. In fact, a considerable number of the "relative effectiveness" studies also included attitude measures as well as tests of learning.

It is interesting to speculate on the reason for this trend. Perhaps it is because television appears to threaten the position of the classroom teacher, or is perceived as a technological device which will take the human element out of teaching and perhaps result in less effective learning.

For whatever reasons, there have been many studies, the results of which have varied tremendously. In some situations students have been quite negative to televised instruction; in others they have been highly favorable; in many studies they have been neutral. It is difficult to sum up the trend so far as student opinions are concerned. Students' opinions are most probably a function of the attitudes of their teachers, or of the quality of the instruction presented to them by means of television. In most cases it would appear that students' attitudes have not been a serious barrier to the use of instructional television.

On the other hand, faculty attitudes have often been somewhat more negative than those of students, and in many institutions of higher learning negative attitudes of the faculty have been the greatest impediment to the use of television. However, when the need to use television is clearly explained and justified (for example, by increased student enrollments, an actual shortage of faculty, etc.), there are usually sufficient numbers of good teachers who are willing to teach on television to make its use viable.

It has been said that "people are often down on things they are not up on." Several studies have indicated that one way of gaining increased faculty acceptance of instructional television is to involve faculty members actively in the planning and conducting of an experiment in the use of television for teaching a course in their own discipline.

Methodology in Attitude Measurement

One of the most interesting trends is in the development of varied methods for assessing students' attitudes to televised instruction. In some studies simple questionnaires have been used which sought to ascertain what students thought about specified aspects of classroom uses of television. Other studies have made use of Thurstone or Guttman attitude scaling methods.

Some experimenters have attempted to obtain indications of attitudes by means of indirect methods such as asking students to "size up" the subjects they were taking, on the basis of several criteria. The experimenters could then see how televised courses were "sized up" in relation to other courses.

In recent years there has been rather extensive use of Osgood's Semantic Differential to assess students' attitudes to instructional television.

Most of the approaches that have been used have employed verbal measures of one kind or another. However, there is a variation of this approach which appears to have many possibilities for assessing students' attitudes as they are expressed in preferences for different methods of instruction. This is the "free-choice" method. A group of students is randomly divided into several sub-groups, each of which receives a different method of instruction. After a certain period of time the groups switch methods for a similar period of time. They are then given a free choice among the methods for several successive class periods, after which the method they choose is the one they must accept for the remainder of the year or semester.

An alternative procedure is to have the students vote on which method they would prefer, following exposure to the alternative methods. Whatever the majority wishes is the treatment that the entire group receives for the ensuing period. This procedure avoids some of the difficulties of verbal measures of attitudes and provides an opportunity for obtaining a measure of actual behavior.

It should be mentioned in summing up this discussion that most of the studies of students' attitudes toward instructional methods have found little or no relationship between attitude toward or preference for different methods of instruction, and actual measured learning from those methods.

The Use of Television to Influence Course-Related Attitudes

One of the objectives of much teaching is to influence students' attitudes toward ideas or issues in certain desired ways. There have been a few studies of the ability of instructional television presentations to change students' course-related attitudes. Generally they have shown that such attitudes, which can usually be modified by the use of appropriate information, are changed in a favorable direction by means of televised instruction and to about the same degree as they are changed by direct instruction.

Additional studies of the factors that produce cognitive attitude changes in students, whether by televised or other methods of instruction, are certainly needed.

Studies of Attitudes Related to Instructional Films

It would seem that the trend in film research so far as attitude studies are concerned is the reverse of that in research on instructional television. Very few studies have been concerned with assessing attitudes toward films as a medium for instruction, whereas a considerable number have been concerned with the use of films to modify students' attitudes, and with the factors that produce attitude changes from film stimulation.

Generally, it has been shown that relevant information presented in films will produce changes in course-related attitudes. The way in which the students perceive the role of the communicator and his prestige *as they see it*, appear to be important factors in the effectiveness of this type of communication. Another factor is the perceived usefulness of the information. Students who believe that the material to which they are being exposed is going to have early use or will be subject to testing at an early date tend to learn more than students who do not have these attitudes. Thus, pointing out the personal relevance of instructional material to students may have an important effect on the degree to which the material is learned.

Studies of Effects of Production Variables in Instructional Television Programs

One disappointing aspect of the research on instructional television over the past decade is the relatively small number of studies that have dealt with production variables or variations in methods of organizing and presenting the program content. This is rather surprising in view of the fact that television production facilities are widely available and it is not a difficult task to develop differing versions of televised lessons or courses for comparison under controlled conditions. Furthermore, it is not unreasonable to expect that manipulation of the stimulus materials which are presented to students might be one of the most likely ways of producing differences in learning.

Some studies reported in the abstracts have dealt with rather gross variables, such as the use of visualization (e.g., pictures, demonstrations, films, diagrams, and discussion panels) versus a lecture-blackboard presentation over television. Others were concerned with the method of presenting information in a television program--for instance, by means of a lecturer, a discussion panel, or interview. Most of these studies have failed to find significant differences in learning. However, a study by Skinner (8) found that an actor trained to perform as a "good" speaker was able to produce significantly higher scores on immediate tests and delayed retention tests than he did when he acted as a "poor" speaker. Another study, by Swarzwalder (6), found that fifth-grade pupils generally did significantly better on a science content test when they had viewed television programs that had planned continuity, visual reinforcement, and had been the result of a team approach to make effective use of the medium. Conversely, in another study of production variables, Ellery (2) found no significant differences in learning of students when exposed to televised programs using such production variables as dollying versus cutting, production errors versus no production errors, a limbo set (no visible background) versus a non-limbo set, and flat lighting versus key lighting.

One very encouraging recent trend is the incorporation of some of the techniques of programed learning into television programs. This involves the inclusion of questions or short problems for students to solve, followed immediately by knowledge of results. Such an arrangement provides for active audience participation, with immediate reinforcement (4,1). It is also an excellent way of working repetition into a television program. An increasing amount of sophisticated research along these lines is predicted for the future.

Another approach that has much potential for improving televised instruction is what the author terms "empirical course development." Briefly, this process involves:

1. Defining course and lesson objectives in terms of detailed descriptions of desired terminal behavior of students.

2. Building, testing, and refining adequate measures of student performance.

3. Selecting content and presentation methods which appear to be appropriate to the stated objectives, and recording these on videotape.

4. Exposing students to the televised course and administering the criterion test or tests.

5. On the basis of an analysis of test performances and on the basis of interviews with students, making modifications in the original lessons and recording revised versions.

6. And finally, comparing the effects of the original version and the revised version on the performances of students randomly assigned to the two treatment groups.

It is anticipated that through the use of this process many production variables could be modified, studied, and evaluated, as well as varied means for producing audience participation.

Studies of Effects of Production Variables in Films

There has been a long tradition in film research going back to the Instructional Film Research Program at The Pennsylvania State University and the studies conducted by the U.S. Air Force, which has manipulated film variables by producing special versions of films incorporating defined variables and then comparing the effects of these versions on appropriate groups of learners under controlled conditions.

This type of research has tapered off in recent years, possibly as the result of a shift of emphasis to research on television and partly because such research studies require good film production facilities and the kind of adequate financing that can only come from a sustained program of research.

Many of the studies of production variables in films included in the accompanying abstracts date from the early and middle 1950's. There are comparatively few recent ones.

Since the variables studied have been so numerous, it is not possible to summarize the results here. It should be noted, however, that several studies have investigated various methods of obtaining audience responses by inserting questions in films or by having the audience call out words.

Other studies have compared inserted titles with no titles, sound films versus silent films with teacher's commentary, motion pictures versus a series of still pictures, animation versus live photography, effects of variations in vocabulary difficulty, and various kinds of attention-directing devices.

A number of these studies have found small but significant differences in learning. However, it should be noted that the majority of studies which have compared black and white with color films have not found that this variable produced marked differences in learning.

There is not the slightest doubt that suitable films stimulate learning and that the way in which films are produced can influence the degree of learning. On the other hand, it would appear that no techniques have yet been discovered for consistently producing large and significant differences in learning.

Research Methodology

In reviewing the film and television research of the past fifteen years, the writer was impressed by two characteristics which were perhaps most evident in the television research. The first is the fact that a number of the studies have deficiencies in their experimental designs. The most common of these were the use of non-random groups and the confounding (uncontrolled mixing) of variables. In addition, some studies used very short tests, and some studies provided no evidence of test reliability. This situation makes interpretation of results very difficult indeed.

The second characteristic of the research is the large number of nonsignificant differences that have been obtained, and even where statistically significant differences were found, there is an absence of differences of large magnitude, say of the order of two to one or greater between different methods of instruction.

It is interesting to speculate on the reasons for the failure to find large and significant differences. Some people have suggested that the measuring instruments are not sharp enough to detect differences which may exist; others suggest that the use of predominantly verbal tests with visual media is the reason. Another hypothesis is that many studies have dealt with comparisons of complexes of variables which tend to cancel each other, while still other experiments were concerned only with single variables which in many cases are not sufficiently potent to produce significant differences in learning.

Another hypothesis is that the "Law of Compensatory Effort" is operating in many learning situations. This law asserts that students have certain levels of aspiration and that they strive for a particular grade. If the instruction is improved in a course which is the subject of an experiment, many students will put less effort into that course and will work harder in other courses which are not being taught as well and where more effort is needed to achieve the desired grade!

In a more serious vein, it is suggested that possibly the most fruitful areas for research lie in the structuring and organizing of the stimulus materials themselves, and in the manipulation and control of student responses. Comparisons among presentations which simply involve different media are not likely to be very fruitful.

Another approach to finding significant differences might be through the use of "additive" designs (3) in which the experimenter begins with a basic treatment and then progressively adds variables, and compares the new combination of variables each time with the basic treatment.

An alternative to this type of approach is the use of the complex multi-variate design involving a considerable number of variables in different combinations. In this situation it may be found that interactions among variables have reinforcing effects on each other, thereby producing significant effects on learning. Results of preliminary studies conducted by Siegel (7) of Miami University at Oxford, Ohio, indicate that such experiments which manipulate the "instructional gestalt" by means of multi-variate designs may be very productive.

The writer would like to make one final plea. Whenever substantial differences in learning in a classroom experiment are found, the study should be repeated several times, using similar but different populations to be sure the results are not due to chance or are an artifact of some specific experimental situation. The building of a tradition for replication of studies in research on instruction is needed.

Meanwhile, the research of the past fifteen years gives some confidence that a variety of media and methods of instruction can be used effectively to meet different needs, and that the determining factors in selecting such methods and media are not so much the effects on learning, as they are other considerations, such as the lack of availability of good teachers, the need to reach individuals in various locations, and perhaps economic considerations.

In the final analysis, it may be that the "best" method of instruction is one that provides students with a wide variety of learning situations, situations which will develop the varied learning skills that they will need for continuing their education throughout their lifetimes.

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COMPRESSED SPEECH

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Resource Materials

Research summaries, reviews of literature, and bibliographies related to the general field of listening are relatively limited in number and scope. In a series of three articles, Witty and Sizemore (36,37,38) summarized listening research from 1892 to 1958. Goyer (19) reported on 46 studies and articles. Duker (4,6) reviewed listening studies in separate issues of the Review of Educational Research. Seeger (29) and Duker (3) prepared unpublished bibliographies. Duker (7) published an annotated, cross-referenced bibliography on listening. Taylor (31) summarized research related to the teaching of listening. Travers (33) reviewed the role of listening in audiovisual communication.

Listening Research in Education

The need for more research concerned with the listening process in education has been noted by many writers (5,19,26,31). It has been estimated that 90 percent of the research concerned with listening has been conducted since 1952 (31, p. 3). Among early investigators were Rankin (27), who was interested in developing a reliable listening test and in finding out the extent to which listening was used as a form of communication, and Stump (30), who was concerned with comparing oral methods with printed methods for presenting test material.

The importance of listening in the elementary school has been pointed out in at least three studies. Wilt (35) found that the pupils she observed in elementary schools spent 57.5 percent of their classroom time in listening situations. She also found that the majority of teachers did not realize the extent of listening demanded of the school child.

Excerpted from Comprehension of Compressed Speech by Elementary School Children. Final Report, U.S. Department of Health, Education, and Welfare, Office of Education, Title VII Project No. 1300, National Defense Education Act of 1958. August 1965. Pp. 6-13, 49-51.

Budoff and Quinlan (1) tested the hypothesis that auditory presentation is often more effective than visual presentation for young children and that this relative effectiveness decreases as the age of the subject increases. They used a paired associates design to compare the aural and visual learning ability of second grade children. The results indicated that aurally presented word pairs were learned more quickly than visual pairs. They concluded that aural learning among second grade children seemed more rapid and more efficient than learning by means of a visual presentation.

Hampleman (20) compared listening and reading comprehension ability of fourth and sixth grade children. The same narrative verbal material was presented either orally or visually to different groups at each grade level. An objective test was used to measure comprehension. The investigator concluded that listening comprehension was significantly superior to reading comprehension at both grades.

Listening Comprehension and Rate of Presentation

There appears to be little agreement as to what constitutes either a normal or a most effective rate of presentation of verbal material. Nichols (23, p. 78) has stated that the normal rate is about 125 words per minute; whereas Taylor (31, p. 12) has speculated that 135-175 words per minute is a normal range, with 150-175 words per minute being the rate preferred by most listeners. According to Travers (33, p. 277), the most effective speed in terms of comprehension is about 160 words per minute. Foulke (14, p. 3) has stated that the normal oral reading rate is approximately 175 words per minute.

Two of the early studies concerned with the effect of changes in rate of presentation were those of Goldstein (18) and Nelson (22). Both investigators used adult subjects and achieved changes in rate through altering speaking speed. Goldstein compared reading comprehension with listening comprehension when identical material was presented aurally or visually at rates between 100 and 322 words per minute. He found listening superior at rates between 100 and 211 words per minute, equal at 248-285 words per minute, and inferior at 322 words per minute. There was a steady decrease in effectiveness from 100 to 322 words per minute. Nelson's results were similar in that a steady decrease in comprehension occurred as the spoken rate increased from 125 to 225 words per minute. However, these differences were not significant within this range.

Another study based on changes in speaking speed was conducted by Fergen (12). She used children from the fourth, fifth, and sixth grades as subjects. The rate was varied from 80 to 230 words per minute in increments of 50 words. Her material consisted of selections from a standardized reading test which were adapted for oral presentation and were read and recorded at the selected rates. Comprehension was measured by a written test. The results showed that at all grade levels the rate of 130 words per minute resulted in maximum scores, that 80 words per minute was superior to 180 words per minute, and that 180 words per minute was more effective than 230 words per minute. She also found a consistent increase in comprehension at all rates from the fourth through the sixth grade, but found no basic differences in comprehension pattern between the upper (M = 119.24) and the lower (M = 83.53) intelligence quartiles.

All three of the studies just cited were dependent for rate change upon the ability of the narrators to speak more rapidly or slowly. Garvey (16, p. 102) has pointed out that the use of such a technique for varying rate may affect timing and enunciation to the detriment of comprehension by the listener.

In an attempt to overcome the limitations noted by Garvey, two technical alternatives for achieving changes in speech patterns were developed; these were the "interruption" and the "chop-splice" processes. Miller and Licklider (21) employed the former in studying speech intelligibility. By turning a switch on and off automatically at various rates from 10 to 10,000 times per second, they interrupted the speech pattern of monosyllabic words. This technique did not involve any saving in time, i.e., there was no compression, but their results did show that there appeared to be an excess of auditory cues in the words tested. If the interruption cycle were rapid enough, as much as 50 per cent of a sound could be deleted without affecting intelligibility.

The forerunner of the electro-mechcnical speech compression method was Garvey's "chop-splice" technique (16). Using college students as subjects, and spondaic words as his material, he magnetically recorded each word on tape and then manually cut (chopped) segments from the tape at regular intervals. The remaining sections were then united (spliced) to form a new and continuous, compressed unit. The results disclosed that 90 per cent or better intelligibility of words was maintained when as much as 60 per cent of a word was removed.

In a further analysis of the results of the above study, Garvey (17) found that for most words, there was relatively little consistency in accuracy among subjects. Also, he found that compressed, consonant phonemes were responded to erroneously more often than were compressed vowel phonemes.

The results of the studies just cited showed that it was possible to interrupt or compress speech sounds rather drastically and still maintain intelligibility or comprehension. They also emphasized the need for improved techniques for altering the rate of presentation of recorded material.

Shortly after Garvey's results involving the use of the manual, time-consuming, chop-splice technique were reported, Fairbanks, Everitt, and Jaeger (9) described a way of automatically compressing recorded material through the use of an electro-mechanical device. This new development greatly simplified the task of obtaining time-compressed material and led to additional studies.

Working with Air Force trainees and using the new time-compression device to prepare material, Fairbanks, Guttman, and Miron (10) investigated the relationship between the extent of comprehension of factual details in two spoken messages and the rate at which the messages were heard. The time-compressed messages were presented at rates from 141 to 470 words per minute. Comprehension was measured with a 60-item objective test. The mean number of items correct at each words-per-minute rate was found to be as follows: at 141 wpm, 38.3; at 201 wpm, 35.9; at 282 wpm, 34.8; at 353 wpm, 27.8; and at 470 wpm, 15.7. As can be seen, at 282 words per minute, comprehension was 90 per cent of that at 141 words per minute, and the material had been presented in one-half of the time.

In another study, the same authors (11) evaluated the effects of listener aptitude and message effectiveness. They concluded that time compression, listener aptitude, and message design all affected comprehension.

Fairbanks continued to explore the time-compression process. He worked with Kodman (8) to study the intelligibility of monosyllabic words which had been time-compressed with varying degrees of discard interval and sampling frequency. They used young adults as subjects. Words were presented at 40-90 per cent compression. The investigators found that with the extent of compression held constant, as the discard interval increased in length from 0.01 to 0.24 second, intelligibility decreased. At each level of discard interval, as compression increased, intelligibility decreased. Maximum intelligibility was reached at sampling intervals between .01 and .1 second at compression amounts of 50 per cent, 75 per cent, and 87.5 per cent.

For almost five years no further studies using time-compressed material were published. Then Foulke and others (15) reported the results of a study using time-compressed material with blind children. The speech-compressor . . . was used to accomplish time-compression, and comprehension was tested at rates from 175 words per minute to 375 words per minute. Two recorded passages, one scientific, the other literary, were presented to blind children in grades six through eight. A 36-item objective test was used to measure comprehension. The mean number of items correct for the various rates of presentation of the scientific material were as follows: at 175 wpm, 20.12; at 225 wpm, 18.69; at 275 wpm, 18.55; and at 325 wpm, 16.17. (The scientific material was not presented at 375 words per minute.) For the literary material the scores were as follows: at 175 wpm, 25.80; at 225 wpm, 24.74; at 275 wpm, 24.21; and at 325 wpm, 16.24.

It can be seen in the case of both passages that at 275 words per minute better than 90 per cent comprehension occurred. Foulke concluded that the test scores alone did not reveal the full educational importance of the experiment. He felt that the time saved in presenting the material was important, especially since the same material was found to be read in braille at only 57 to 70 words per minute.

Orr, Friedman, and Williams (25, p. 15) reported that their research showed that college students could comprehend compressed speech at 325 words per minute with only slight loss in comprehension.

It would appear, based on the findings of Fairbanks *et al*. (10), Foulke *et al*. (15), and Orr *et al*. (25) that a high degree of comprehension can be expected when compressed speech is presented to naive listeners at rates of from 275 to 325 words per minute.

Although the results of experiments concerned with training subjects in listening to compressed speech are not conclusive, it appears that higher effective rates are possible when subjects have had some prior exposure to increased rates. Voor (34), for instance, found that subjects exposed to material at 380 words per minute improved in comprehension with practice. Orr (24, p. 460) has indicated that with a small amount of training, a rate of 425 words per minute can be used with 80 percent comprehension. Foulke (13), on the other hand, found that neither of two different methods of training resulted in significant increases in comprehension at 350 words per minute.

In two additional studies, Foulke (13) found (a) that retention of compressed speech material followed a pattern similar to that for retention of material delivered at normal rates, and (b) that differences between reading style and voice quality of narrators affected the comprehension of normal and fast rates in like manner.

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TEXTBOOK DESIGN AND ILLUSTRATION

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The pressure of modern social evolution with its exploding demands for more knowledge and more education has created a great upsurge of interest today in all things educational--the teacher, the student, the schools, educational methods, visual aids, television teaching, and even mechanical devices to substitute for teaching. Only one major aspect of the educational process has not been put through lengthy reappraisal, the books used in teaching. A scientific appraisal of the principles of the artistic design and illustration of textbooks is the object of this study.

What is the science of book design? How can more effective textbooks be developed? Can we start a new program of book design? Can we develop a scientific theory to guide us in designing books that will also give us insight into the fundamental nature of reading and writing? Or, are books on the way out as teaching devices, to be replaced by mechanical gadgets, tape recorders, and television sets? These are the beginning questions of the science of book design which we can attempt to deal with in the future.

The theory of book design is a part of the theory of verbal learning. Today in psychology, a special point of view called "reinforcement theory" dominates thinking about verbal learning. Reinforcement theory reduces the problem of acquisition of meaning to the strengthening of the specific verbal response by feedback to the individual of some rewarding outcome in the use of the word. The general point of view presented here denies, on the one hand, the arithmetic nature of this reinforcement process in reading and emphasizes, on the other hand, the role of perceptual or artistic reinforcement.

We relate the functional or organic theory of reading to be discussed here to the historical facts about the origins of writing and

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reading. From the outset, in the calendrical picture writing and in ownership seals of ancient Egypt, reading and writing have been related to picture art. The hieroglyphic symbol, or sacred writing, represents the highest point of picture writing, after which the written symbol came to be related to the sounds of speech. The abstract lines of thought in Greece and the influence of later religions on thinking separated writing and books from picture art. It is this abstract tradition in book design that we inherit. With the modern explosive expansion of technical knowledge, the two forms of manual expression--picture making and symbol writing--have been joined together again, not only in the form of concrete representation of things, but also through the use of abstract line designs and graphs which describe the interaction between events. Our purpose here is to interpret this history of writing and artistic illustration in relation to scientific concepts and principles of book design.

The general ideas here are not only theoretical in nature. Most of them have been applied in the design of an artistically illustrated textbook (Smith and Smith, 1958) and an artistically illustrated workbook in psychology (Smith, Smith, and Hansche, 1958). Samples will be taken from these books to illustrate the use of artistic drawings in directing, strengthening, and motivating the individual to read and of the design of books to improve reading.

Principles of Illustration

The general idea pursued here is an organic or functional theory of textbook design. When we use the term organic we mean that the design of the book and its illustrations must emerge from several integrated sources--the materials and machines of printing, the specific requirements of subject matter, and above all, from the natural processes of behavior and communication--both verbal and nonverbal--that go into reading and study. The view proposed and applied here is that these natural processes of communication in textbooks demand the use of various forms of impressionistic, representative, and abstract illustration in order to bring effective organization to textbooks and to create books which not only meet the perceptual and artistic needs of the student, but also refine his understanding of what is read, improve his retention of material, and stimulate the development of creative thought.

Creative art in books serves three main functions. First, it serves to perceptually motivate the reader--to attract him to pick up the book, to explore it, and above all to develop a high feeling of expectancy in turning each page. Second, artistic illustration perceptually reinforces what is read, so that the situations, events, and relationships described in words are made more meaningful and thus are better retained. Finally, correlated art symbolically enhances and deepens the meaning of the verbal material and thus serves to advance organization of the verbal materials to promote creative thinking.

This organic theory of reading puts stock in some of the most favored features of books, as compared to mechanized, controlled instruction by mechanical or electronic means. Books confer a freedom on the student that these controlled means of instruction do not. The reader can flip pages at will, seeking expression of his own interests and needs, probing deeply into difficult subjects, and passing over what is well known. The general theory under discussion suggests that these salient features in books can be enhanced through creative art, that the reader's probings can be deepened by better vision, and that his motivation can be increased by artistic programming of subject matter.

Perceptual motivation and art in reading. Reading is always in part a perceptually motivated activity. It may involve other motives, such as the pressure to study or to cope with examinations, but it also consists of activity directed and sustained by observing visual patterns (words) and by the perceptual relations, actions, and situations created in the experience of the reader by the words.

Artistic illustration can strengthen perceptual motivation in reading by giving immediate perceptual organization to the environment created by the printed matter and the situations and actions described. If a book is not illustrated, the reader perceptually reconstructs and projects himself into the events and situations of the book through the process of verbal symbolism. Art quickens this organization, and gives to words an immediate meaning which the reader, through his limited experience, may not be able to develop.

This artistic enrichment of a book creates what we all the "perceptual space" or "environment" of the book. In order to create a rich perceptual human environment in the book on behavior, a great variety of illustrations of people were used, as shown in Figure 1. People of different ethnic origins and of different ages, size, form, and manner were shown. For example, Figure 1b describes a panel of personalities which was employed to symbolize the field of individual differences. The belief is that the well-organized perceptual environment provided by such illustrations gives the reader a continued feeling of familiarity with his surroundings, and one that is seemingly animated with human life.

Art can increase perceptual organization during reading in a second way, which we might call artistic segregation and programming of the reading material. By these terms we mean the highlighting of main concepts, events, and situations in the reading by illustrations in a progressive and systematic way.

Some of the possible techniques of artistic programming which have been used are shown in Figure 2. At the beginning of each chapter of a book a theme drawing, usually of an abstract nature, is used to set the stage for the main characteristics of behavior to be described in the chapter. For example 2a is meant to suggest the almost infinite detail of human perception, as well as its characteristic object and space properties. Descriptive sequential and classificatory drawings, such

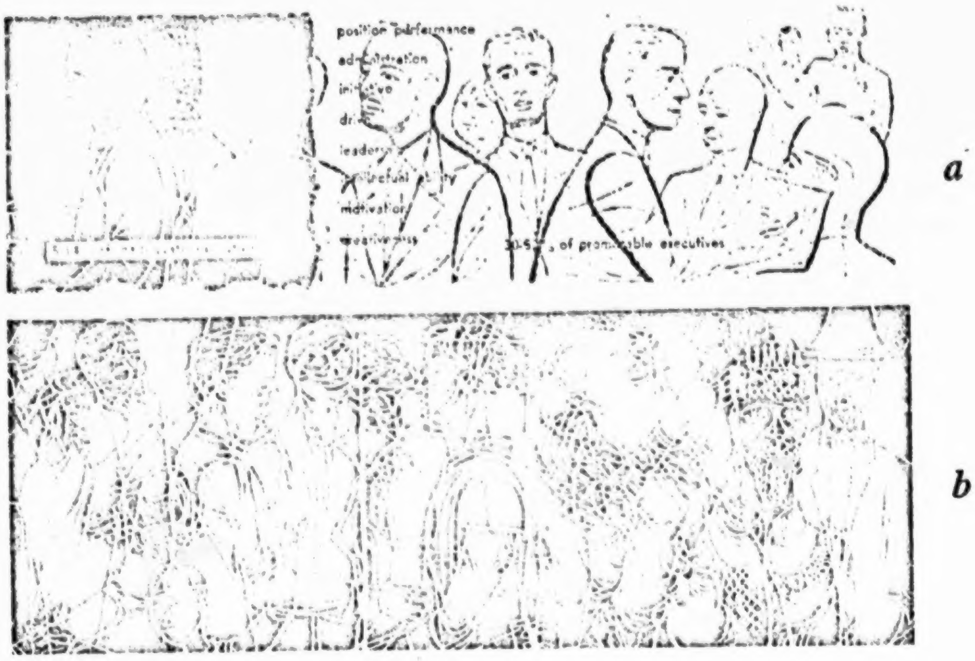

position performance
administration
initiative
leadership
motivation
creativeness
of promotable executives
a
b

Figure 1. The creation of an integrated perceptual environment within a book by means of sustained artistic illustration.

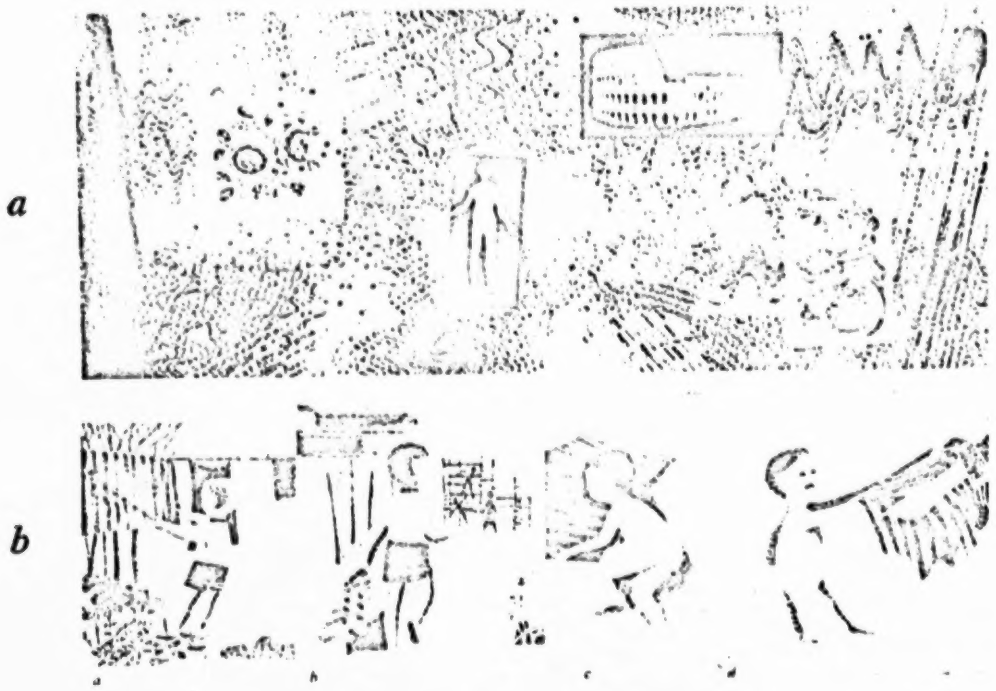


Figure 2. The techniques of artistic programming. (a) Abstract and expressionistic designs set the stage and define artistically the theme of a chapter. The design shown here illustrates the infinite detail and object qualities of human perception, along with the physical forces governing it. (b) Sequential drawings classify parts, stages, or sequences of events within a topic. The four drawings illustrate four stages in the perceptual motivation of the child for his blanket.

as the illustration of the perceptual motivation of a child for his blanket (Fig. 2b), are used in introducing a subject in order to establish familiar ground plans before the later introduction of detail. To illustrate such detail, highly representative drawings, sometimes combined with line or bar graphs, are used.

There are still other techniques of artistic programming of subject matter. The initial subject drawings in a chapter are made easier to understand and more general in their meaning than those illustrating more detailed subjects. Later drawings in the same chapter describe detail and interactions. Other drawings spell out complex sequences and classify events in many different ways. Still others illustrate theoretical ideas and relationships.

A third function of creative art in reading motivation is to promote the natural curiosity of people to explore, to seek new things, while still holding securely to things they already know. The importance of such exploratory, or general perceptual motivation has been recognized by psychologists for years as a primary form of both human and animal motivation.

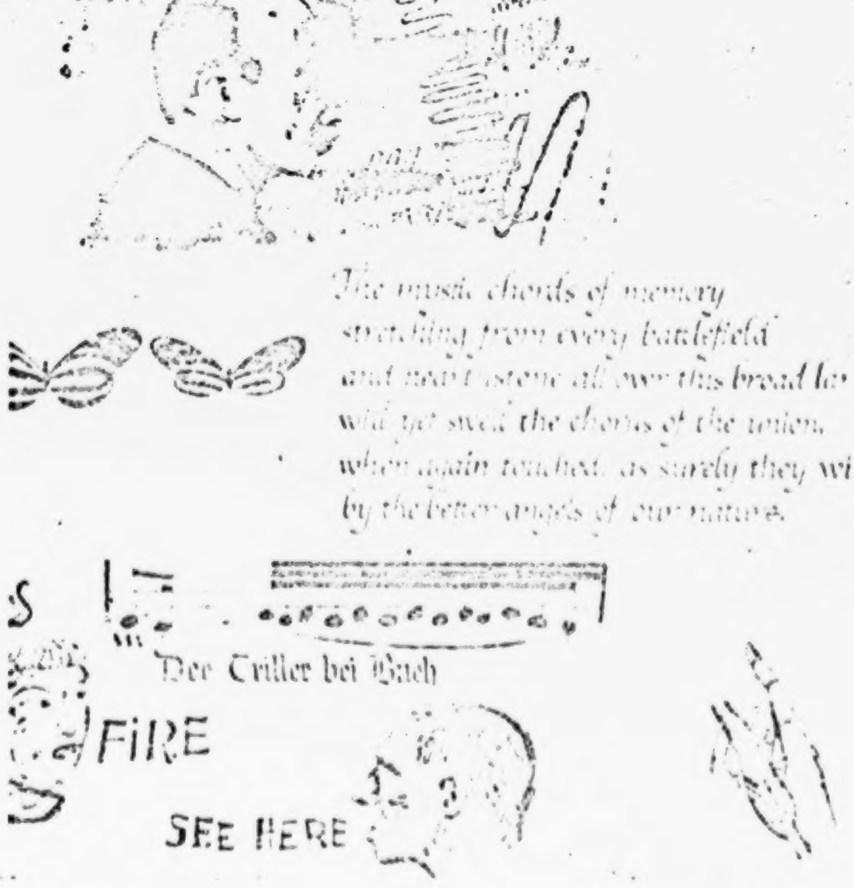

The mystic chords of memory
stretching from every battlefield
and heart stone all over this broad la
will yet swell the chorus of the union,
when again touched, as surely they wi
by the better angels of our nature.
Der Triller bei Bach
FIRE
SEE HERE

Figure 3. Artistic enhancement of symbolism and thought in reading. The exploratory drawing is used to promote investigation and curiosity about relationships discussed only in part in the text.

Exploratory perceptual motivation is promoted by artistic illustration in two ways--by what we call the exploratory drawing and by use of unusual and varied art forms.

Figure 3 identifies a type of exploratory drawing. This drawing combines a series of fairly familiar things in an unusual relationship. There is a picture of a familiar face (Max Planck), a section from Lincoln's second inaugural address, a chord from Bach, a monk, a Neanderthal man, and a pointing hand. All of these symbols are indicated in the text as representing the pointing, signaling, symbolizing, motivating, and abstracting functions of language. The drawing is given a caption, but the specific meaning of each figure is not described. The student must explore with some help from the text.

Figure 4 describes some unusual artistic techniques which have been tried in order to create theme drawings of an abstract or expressionistic nature which are employed to introduce different chapters in a book. Figure 4a is an expressionistic design of the dynamic relationships in human adjustment. Figure 4b is a special photographic study of human hands, combined in unusual relationships in order to illustrate emotion. Figure 4c is an oil emulsion effect produced on clear film by combining oil and India ink. The design was used to introduce a chapter on the organic or bodily mechanisms of human behavior.

Artistic reinforcement of verbal symbolism in reading. We identify a second function of art in book design. The view is that artistic illustration strengthens the learning process by providing additional experiences which confirm and extend the verbal responses. We call this artistic or perceptual reinforcement of reading. It involves information feedback from the artistic displays which serves to strengthen the symbolic responses of the reader. Such feedback is comparable to goal reinforcement in general learning where it consists of achievement of some reward or goal through reaction of the individual. The behavioral goal achieved reinforces or strengthens the response that led to it, and causes this response pattern to be retained better in memory than one which is not reinforced.

The goals of reading activity are primarily perceptual in nature, as suggested by the symbolism of words and sentences. To reinforce the acts of reading, we make these goals clear and definite by illustrative art. We use the artistic drawing to feed back information to the reader which confirms and strengthems the symbolism of the reading material.

The theory under discussion specifies a number of principles, one of which is to align subject matter and related art as closely as possible on the page. To achieve this alignment, the page of the book must be designed to accept the art. We have introduced the art column in a book, a half column that can be used for both illustrations and captions. When necessary, this space can be combined with column space for larger illustrations. The flexibility of this page design permits very close alignment of subject matter and art in most cases.

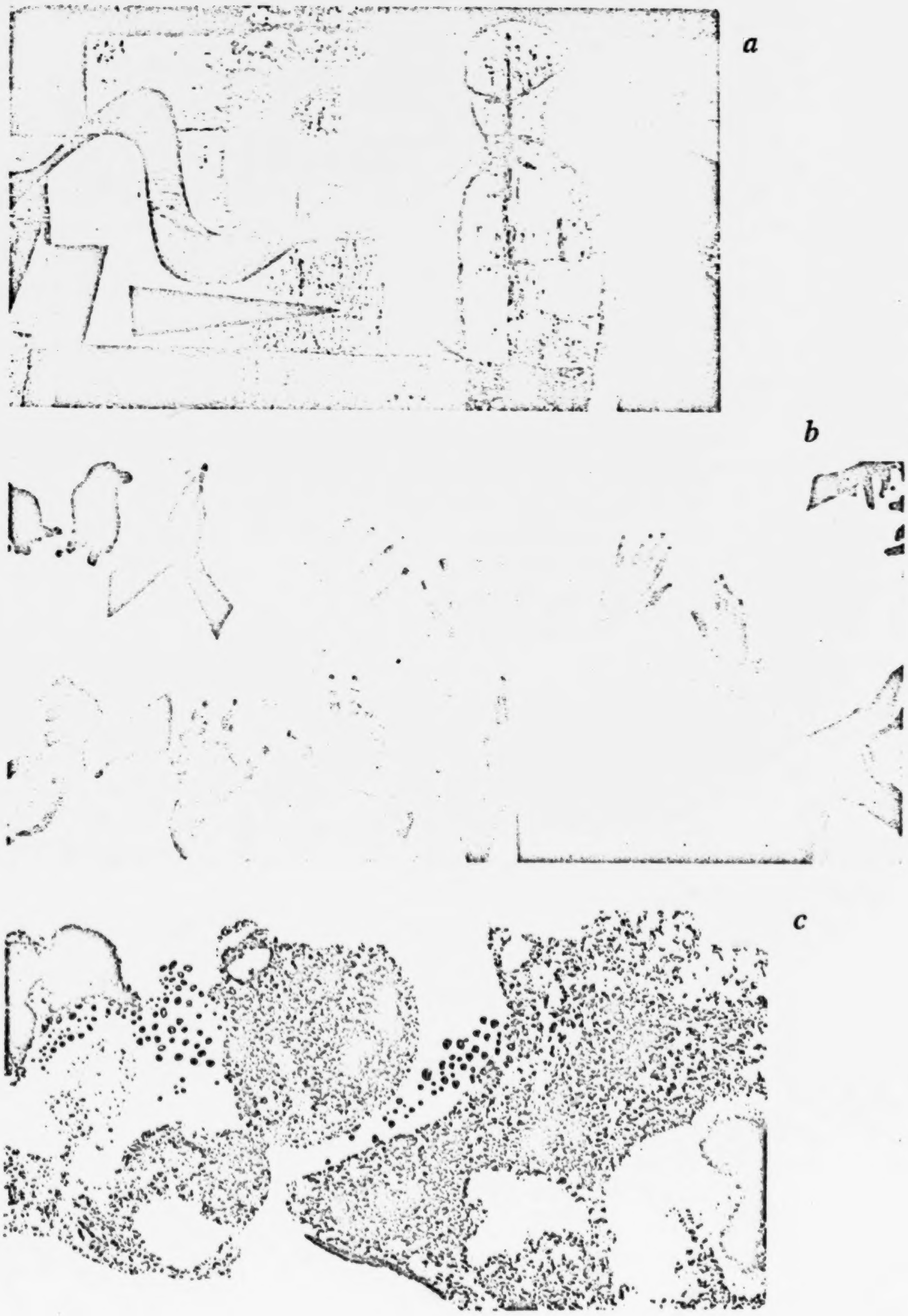


Figure 4. Techniques of artistic programming in reading. (a) An abstract design is used to define environmental and individual interaction in adjustment. (b) A photographic montage of hands illustrates the behavioral expression of emotion. (c) An oil-emulsion design on plastic provides the essential impression or organic detail.

A second principle of perceptual reinforcement which we have developed is the close coordination of verbal, graphic, and artistic descriptions. Interlocking text with drawings and graphs is especially effective in describing experiments, as shown in Figure 5. A drawing of the whole situation sets up the initial description of what goes on. A second stage drawing illustrates a critical detail also described verbally. Finally a graph presents the quantitative results of the observations. In this way, each stage of a sequential drawing reinforces the verbal symbolism as well as the prior stages of the drawing. The drawing in Figure 5 illustrates the stages of an experiment on perceptual motivation in the monkey. The monkey is trained to discriminate between a white and black door by rewarding him for a correct choice. (If he chooses correctly, he is allowed to look out of his box.) The graph shows the learning of this discrimination habit.

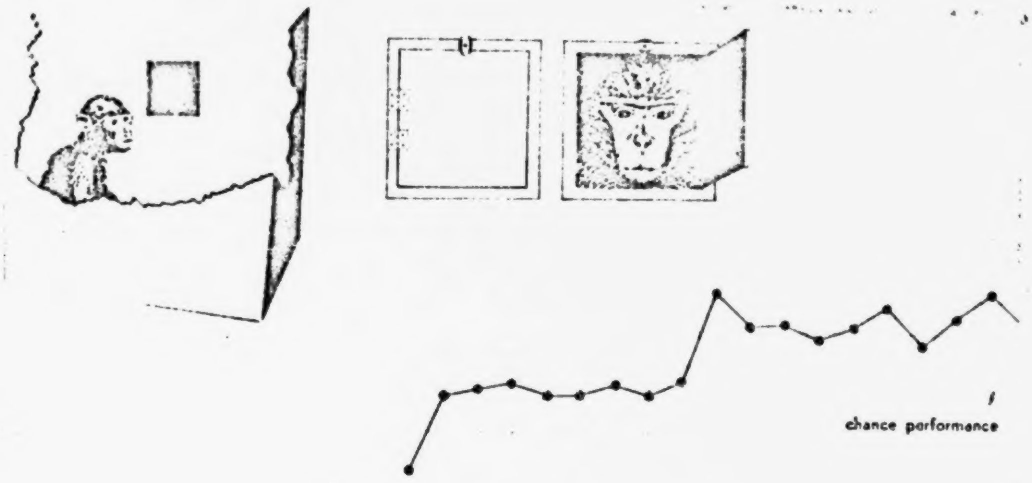
A third principle of perceptual reinforcement in reading is to sharpen the verbal presentation by artistic means. We use bizarre drawings to characterize bizarre subjects, such as dreams. We use sequence and stage drawings to coordinate with descriptions of interrelated sequences and stages of experiments and other behavior. Many full-color paintings and photographs illustrate color phenomena of visual perception.

One technique used to sharpen and thus reinforce descriptions of social behavior is to portray groups of people as if observed from a vantage point high above them (Fig. 6). Such drawings create the illusion of actual observation of social events. These drawings also make possible diagrammatic representation of groupings and interrelationships among individuals and groups.

Another method of artistic sharpening which has been tried involves matching the design and execution of a drawing with the time and nature of the particular topic with which it dealt. An example of this matching in Figure 7 shows a panel of primitive figures designed to illustrate the primitive origins of language.

There are still other ways to correlate subject content and artistic illustration. One is to utilize the special artistic talents of different contributing artists and their feeling for certain subjects in the execution of particular drawings. In this way, techniques of execution are fitted to the particular subject. As a result, drawings of different subjects--animals, children, males, females--are differentiated by artistic techniques as well as by the topics with which they deal.

Artistic enhancement of creative thought in reading. To appreciate the functions of artistic illustration in promoting creative thought, the difference between verbal and nonverbal communication and their complementary relationships need to be recognized. The effectiveness of spoken language depends not only upon verbal communication, but also upon nonverbal patterns, including gesture, emotional expression, tone of voice, inflection, and posture or body language. Written language ordi-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chance performance

Figure 5. One technique of perceptual reinforcement in reading. Integration of artistic and graphic descriptions of behavior, which are described in the text in sequence.

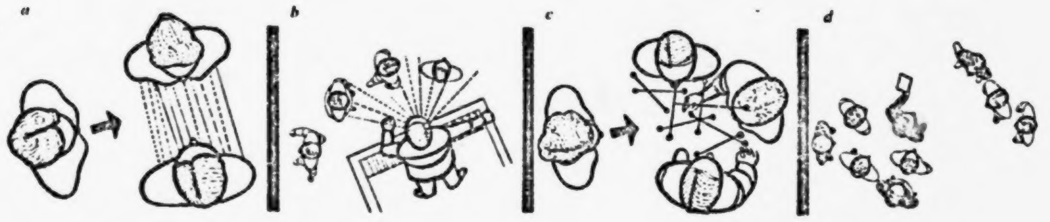


Figure 6. Techniques of perceptual reinforcement. Drawings of social behavior reveal the impression of observation of such behavior at a distance or other vantage points.

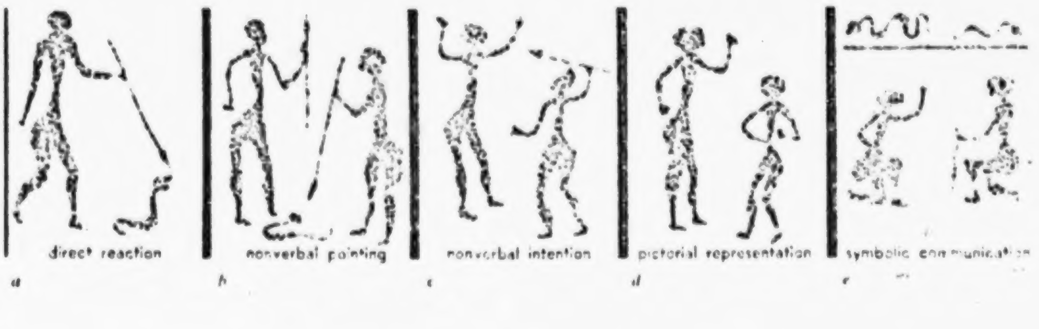

direct reaction
nonverbal pointing
nonverbal intention
pictorial representation
symbolic communication
a
b
c
d
e

Figure 7. Techniques of perceptual reinforcement. The execution of a drawing is made to correspond to subject matter. In this case a primitive type of artistic execution is made to depict the primitive origins of language symbolism.

narily lacks the context of nonverbal communication characteristic of oral speech. Unadorned writing substitutes for this nonverbal base various techniques of individuality in writing or literary style. However, artistic illustration can be used to give a foundation of nonverbal communication to written language, thereby promoting originality and creativity in the reader's symbolic responses.

The artistic enhancement of creative thought in reading involves principally the matching and interplay of different forms of art--representative, abstract, and impressionistic--with the demands for concrete description, clarification of abstract relations, and expression of emotional tones and values in the writing. We have tried out various forms of artistic illustration matched with different types of abstract, evaluative, and concrete subjects.

Some artistic impressions of human events related to mental illness are shown in Figure 8. From our point of view, these drawings accomplish what no series of photographs or even actual observations of mental hospital patients could do. They give a symbolic interpretation of individuals in difficulty within the strange environment of mental illness, and they do this with a persisting compassion for the people and a consideration of human values. They invest the word meanings of the text with the immediate potent nonverbal impressions and meanings of artistic symbolism. The interaction within the reader between these two forms of symbolism, one verbal and the other nonverbal, may very well be the key to a whole new line of creative thought on the part of the reader.

We use abstract art as a form of nonverbal communication correlated with abstract concepts defined in the text. As examples, abstract designs illustrate dynamic phenomena of force, energy, motivation (Fig. 9b). Such dynamic phenomena can never be described adequately by words alone. Abstract art, along with such visual representations as the quantitative graph and the mathematical formula, can be used to give nonverbal meaning to descriptions of dynamic relations and interaction of events.

Another type of drawing used to promote creativity in thought through nonverbal communication is the exploratory drawing, which is captioned but not specifically labelled, as already discussed. We believe that the exploratory activity generated by such drawings is in itself a process of creative thought not far removed from research.

Application of Principles

The workbook is the original "teaching machine." It too can be designed in terms of specific principles of artistic illustration in order to promote perceptual motivation, learning, and creative thought in reading and study. Several new ideas of visual design have been tried out in preparing a general workbook for a psychology textbook.

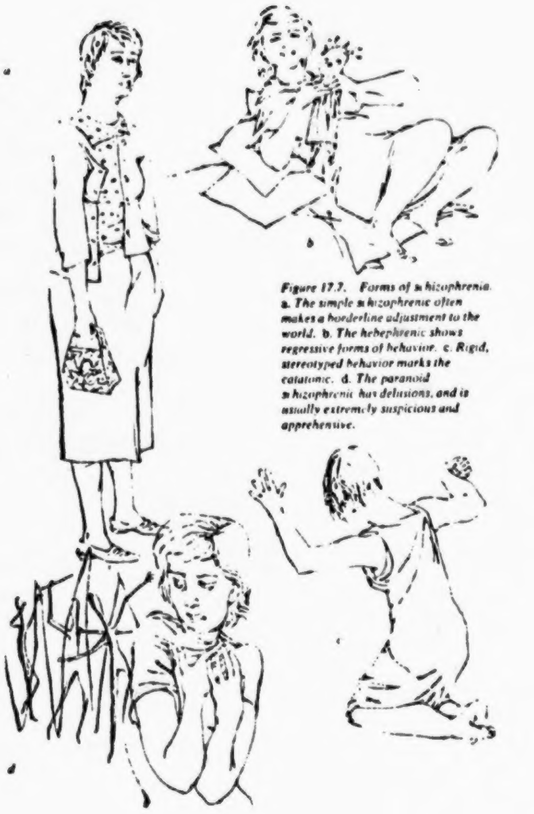


Figure 17.7. Forms of schizophrenia. a. The simple schizophrenic often makes a borderline adjustment to the world. b. The hebephrenic shows regressive forms of behavior. c. Rigid, stereotyped behavior marks the catatonic. d. The paranoid schizophrenic has delusions, and is usually extremely suspicious and apprehensive.

Figure 8. Artistic enhancement of symbolism in reading. A drawing of behavior in mental illness enhances the human values of behavior disorder.

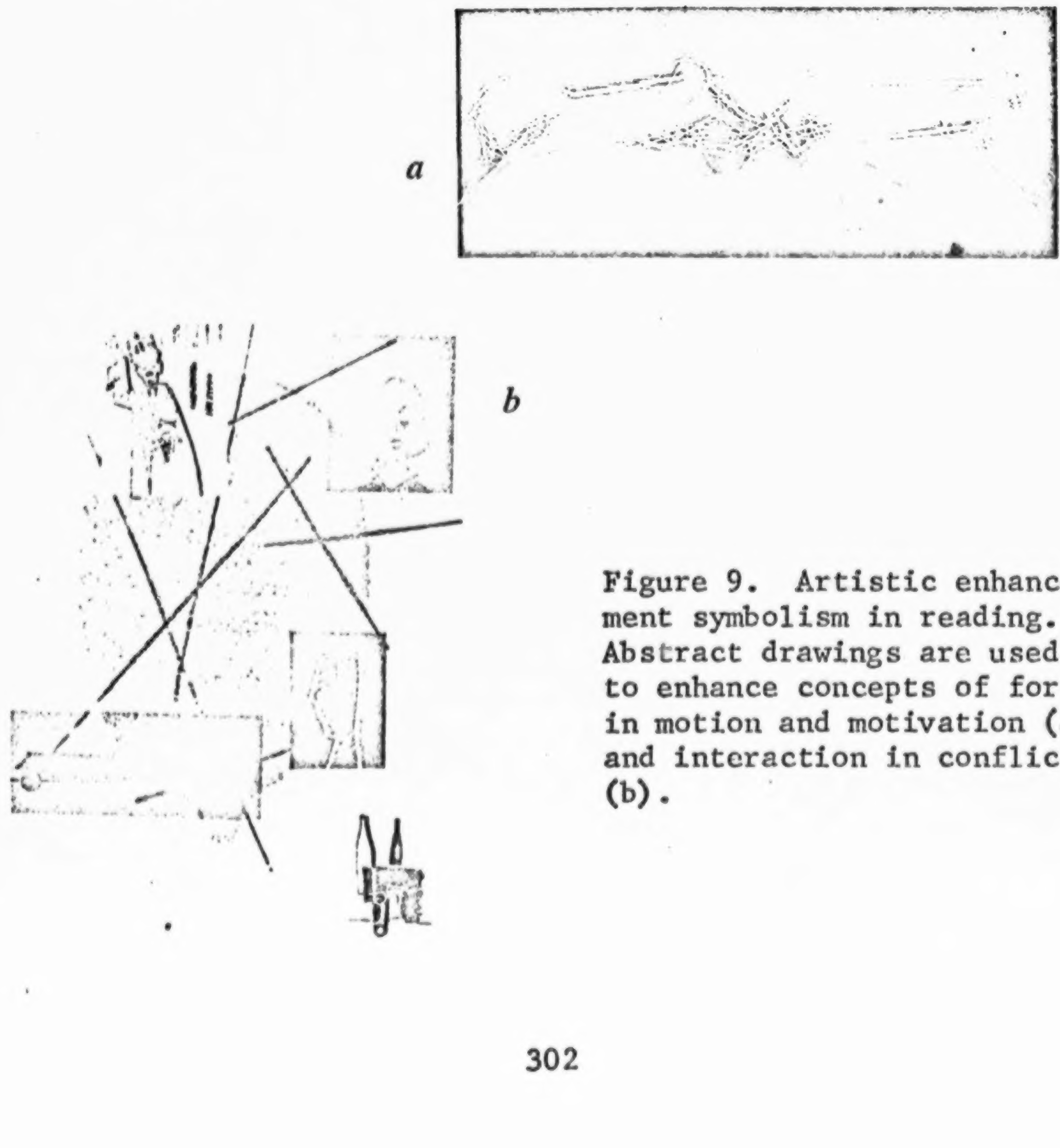


Figure 9. Artistic enhancement symbolism in reading. Abstract drawings are used to enhance concepts of force in motion and motivation (a) and interaction in conflict (b).

The general theory of workbook design is that visual art provides the essential perceptual materials with which the student can work in answering general questions, solving problems, answering self quizzes, or doing projects contained in the workbook. If there are no rich sources of materials to guide the work, as there are in the social sciences, most students find a workbook unrealistic, too abstract, nonchallenging, and unrewarding as a task. Correlated visual art in a workbook, extracted and modified from the related textbook, provides the means of promoting and aiding transfer of learning from the textbook to the actual work efforts by the individual student.

Our notions of the design of workbooks follow in general the principles already discussed. We demand a lot of illustrations to keep a varied environment for the student. The workbook itself is divided into chapters headed by an abstract drawing or photographic montage which is related to an introductory paragraph giving a general discussion of the subject. On this first page of each chapter, space is provided in which the student must write out some eight to ten definitions of general concepts dealt with in the related chapter in the book. Such an introductory page can be varied artistically in many ways. The montage can be made to illustrate specific concepts or high points which must be defined. Or any essay question can be required covering the subject illustrated in the theme drawing.

Figure 10 illustrates how artistic illustrations are used to perceptually motivate the student and to reinforce his own efforts in answering essay and completion questions. An illustration used in the book is modified in some ways and reproduced in the workbook. Captions are eliminated and significant legends, used in the original illustration, are omitted. The student is then asked to write a short essay covering the subject related to the illustration. Or a series of completion questions on the subject may be prepared.

The diagram in Figure 10b, for example, is a modification of an illustration of an experiment on perceptual restriction. Legends and other details are missing, as compared to the illustration in the textbook (Fig. 10a). The student is asked to write a short essay on the experiment illustrated in the drawing. The drawing in Figure 11 gives an example of relatively complete artistic support for the student in answering a series of completion questions. This drawing illustrates the interactions of personality indicated by the Freudian theory of psychoanalysis. The drawing is almost identical to the equivalent drawing in the textbook, except for some reduction in size and elimination of the caption. The related completion questions require the identification of the founder of psychoanalytic theory, the elements of motivation of behavior in this theory, the levels of personality, the dynamics of personality development, and the nature and effects of conflict between different levels of personality.

In the workbook, abstract drawings are sometimes substituted for representative drawings, or specific concrete illustrations are given

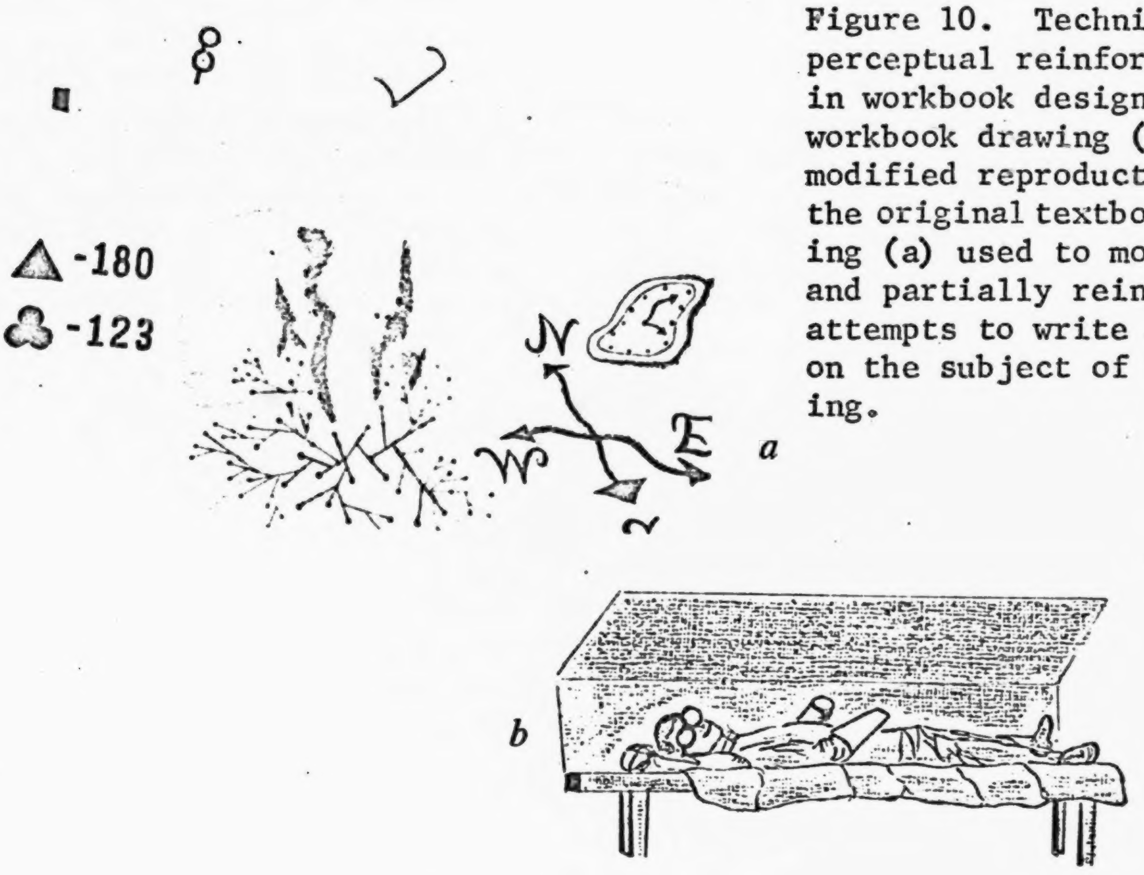


Figure 10. Techniques of perceptual reinforcement in workbook design. The workbook drawing (b) is a modified reproduction of the original textbook drawing (a) used to motivate and partially reinforce attempts to write an essay on the subject of the drawing.

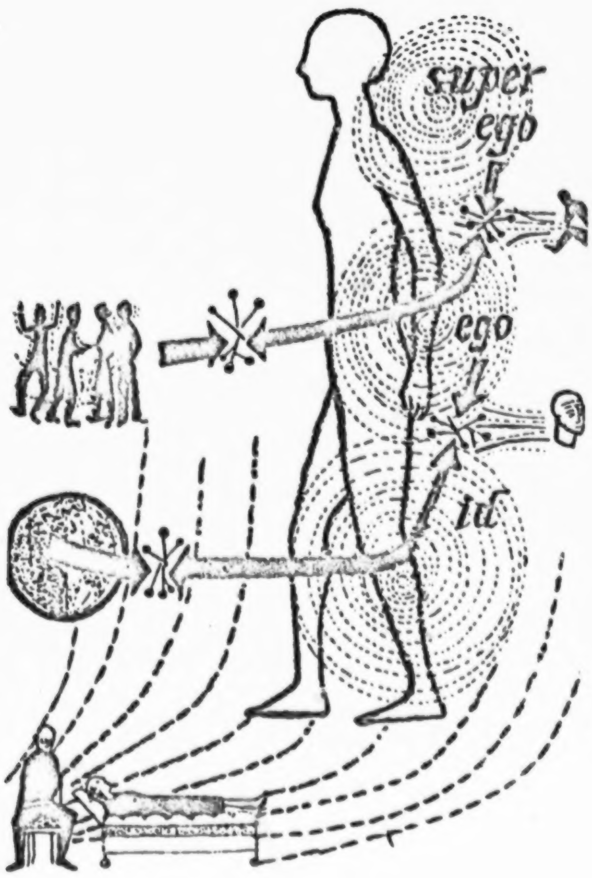


Figure 11. A drawing illustration of psychoanalytic conceptions from the book is altered slightly for inclusion in the workbook and used as a visual reinforcer for answering a series of completion questions.

of ideas illustrated by general drawings in the textbook. Sequential drawings in the textbook are put in different order in the workbook, and questions presented about the experiments or ideas are thus rearranged. Original workbook drawings or modified drawings from the textbook are used to set up matching questions and individual projects.

The general ideas followed in the design of workbooks are thus an extension of the scientific and artistic principles of textbook design. Textbook art is much more than just pictures or comic-book technique. It is a complex tool of nonverbal communication which can be applied in many ways to motivate and reinforce learning, and to promote transfer of learning from a reading context to the individualized work situation in study. Moreover, correlated art in textbooks is an indispensable instrument in advancing creative individual thinking in study and in reading. Impressionistic art deepens the processes of creative thought in relation to human values, feelings, emotional tone, ideals, morals, and cultural factors. Representative drawing is the tool of classification, of demonstration, and of depicting processes, operations, and concrete examples. Abstract act, of which the bar and line graphs are functional derivatives, has all kinds of indispensable applications in textbook design--to give life to illustration and symbolism of all phenomena of interaction and dynamics, to create curiosity about unknown relationships, to demonstrate relativity of events, and to generalize at the perceptual level.

Procedures of Artistic Illustration

Many original ideas are being developed today about the procedures of improving books visually and artistically. Hogben (1959) has spoken of a "New Look" which can be achieved by the use of professional illustrators in the publishing business. Here the illustrator serves both author and publisher in producing illustrations suggested or laid out by the author.

We have ideas about the procedures of book illustration which differ from the above arrangement. In our opinion, the integrated artistic illustration of textbooks cannot be achieved by arranging commercially executed illustrations in relation to the printed galley. The book must be written from the outset around illustrations, and the demands of the visual art must be met in the revision and editing of the final manuscript. Just as an illustrated lecture demands timing and interplay of speech and vision, the visions and symbols of an illustrated book must interact in their effects to produce a uniform flow of verbal and nonverbal artistic communication.

Here are the steps in a program worked out in relation to this general theory of book design. The first draft of the book is written around illustrations prepared by the author. In making his preliminary illustrations, the author works with two ends in view--to get illustrations that will serve the artistic functions of the book and to achieve drawings that will communicate with the artist.

A basic secret of interaction of author and artist is the fact that their communication must be carried out largely at the nonverbal level, through the use of the author's drawings. The author must learn the varied uses of representative and abstract drawings and must know how to exploit the value of simple abstract designs in conveying the needs of artistic meaning to the artist. Thus from the first draft, the manuscript is prepared to incorporate the illustrations as an integral or natural part of the communicative process of the book.

The initial plan for overall design of the book must take into consideration the number and variety of illustrations. After a plan is drawn up for the format, size, type, color, and special arrangements, and an agreement reached with the publisher, the artist-designer and the author can then proceed to finish the preparation of the book.

The artist-designer is given a copy of edited manuscript, along with the author's preliminary drawings for each chapter. Tentative artistic layouts specifying exact proportions are prepared from this material. Author and artist then discuss the desired illustrative effects for their layouts.

In order to achieve true artistic expression, the artist is left free at all times to execute layouts and finished drawings according to his own lights, as long as the general purposes of an illustration are not violated. The author can criticize a drawing as to accuracy or content, but not as to artistic effect, which is the domain of the artist. In this way, the artist can make a truly original contribution to the book and bring out novel illustrative approaches to subjects. He cannot make this contribution if he works according to specific directions.

After preliminary layouts are completed, they are checked for accuracy by the author. If the artist is doing an original job, his contributions will lead to revisions in the manuscript. The final manuscript will thus combine the verbal and visual conceptions of the author, the suggested changes by the editors, and the artistic additions by the artist.

The final drawings are prepared by the artist-designer or by contributing artists. When these drawings are done, the last stage of the work in page design is executed. The original design of the book, if effective, will expedite this process. As noted earlier, we developed the concept of the art column in the textbook, a marginal half-column that can be used to adjust both illustrations and captions to fit a given drawing to the text of the page.

The final page designing can be done from galley proof supplied by the publisher, or from typed manuscript. We have tried the latter procedure with some success, but also with some difficulties in keeping the page plan exact. The artist-designer uses a carefully-prepared manuscript which is typed so that the line length of the manuscript will correspond with the line length of the column of the book. He sets up the page design and dummies from his own layouts and by computing the number of words per page from the typed manuscript. When the page dummies are finally prepared by the publisher, minor changes can be made in the manuscript to keep the text "in step" with the illustrations.

Figure 12 illustrates some of the stages of evolution in the author's preliminary drawing, through the artist-designer's layout, to a final illustration of symbolism in dreams. Figure 12a gives some idea of how the author attempted to achieve illustrative effects which could promote rapid effective communication with the artist-designer, but still not commit him to a specific concrete mode of execution of the subject. The abstract drawing gives the artist leeway to execute his own layout in terms of many different illustrative effects.

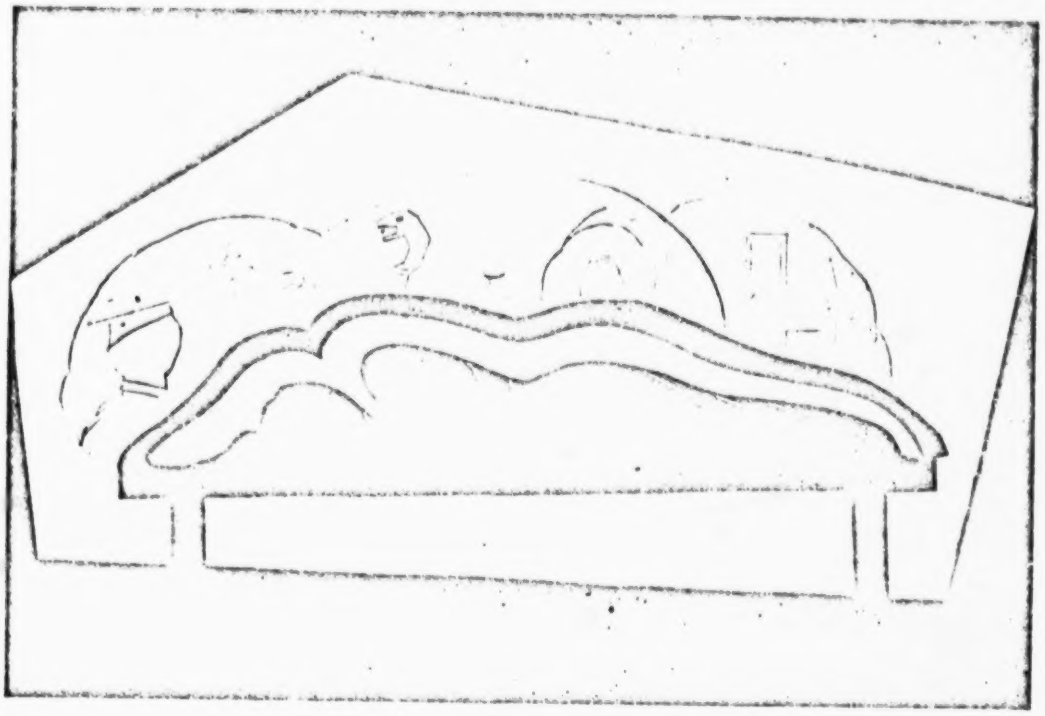
The layout of the artist in Figure 12b is much more concrete and detailed than the original drawing of the author. The essential form of this drawing is followed by the contributing artist, whose production (Fig. 12c) is a bizarre integration of pen drawing and the use of old engravings to achieve a special artistic effect.

The general conclusion from our experience covering the preparation of several hundred drawings by many artists, is that the essence of communication between author and artist is nonverbal. The disappointments which authors experience in trying to communicate with artists by verbal direction may be predicted from our theory that artistic communication is by nature not subject to verbal expression. Our experience is that the use of the author's drawings, prepared in both abstract and representative form, eliminates most of the problems of author-artist communication. The author's sketch is not enough. Poor art from the author probably means poor art in the book.

Theory of Textbook Design and Illustration

The systematic principles of textbook preparation just discussed constitute in effect a theory of textbook design. We have been interested in this theory, not only to guide us in preparing specific books, but to advance the scientific study of textbook design. Such study, aside from some observations to be reported here, has yet to be conducted in a systematic way.

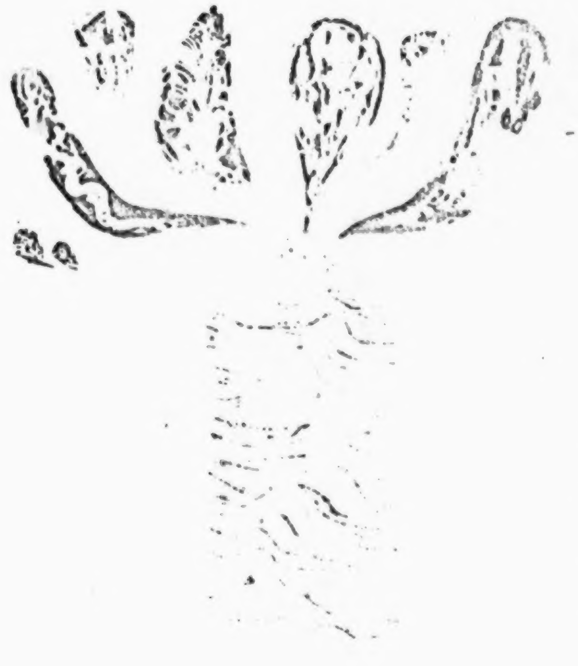
Our general point of view was stated earlier. Books must be prepared according to principles of organic design. They must reflect and provide for various levels of natural behavior, symbolism and communication, both verbal and nonverbal. To achieve such an integral confirmation of inner organic or emotional communication, as well as concrete and abstract symbolism, impressionistic as well as representative and abstract drawings are used to give substance to the verbal symbolism. According to this view, the coordination of art and writing is a natural expression of symbolism in thinking.



a

Figure 12. Variation in artistic conception of a subject (dream symbolism). (a) Author's preliminary drawing. (b) Layout artist's drawing.

b



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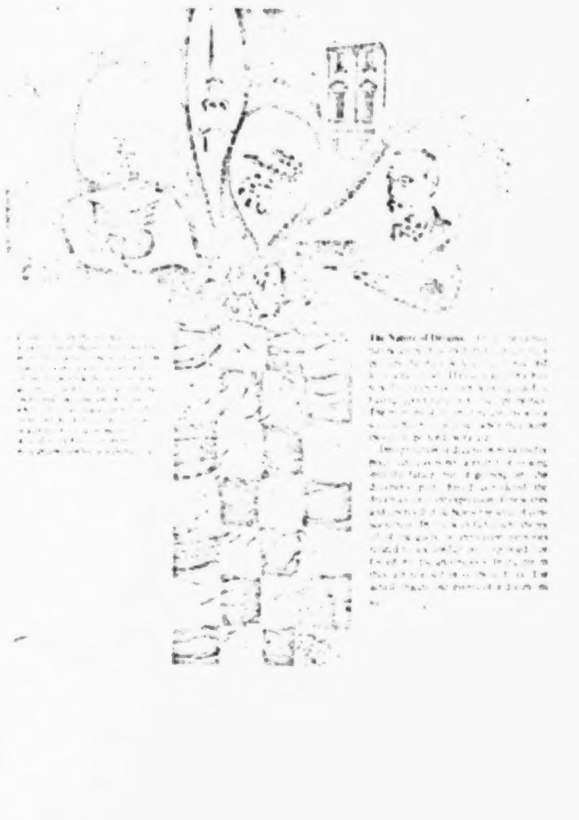

(c) Final drawing by a contributing artist.

The organic interrelation of verbal and artistic communication is of historical origin. Art is ageless in its impact on the observer. Historically, writing was derived from artistic symbols--pictorial images representing objects and their relations in space. In the evolution of creative thinking, art and writing complemented each other and contributed to their mutual progress. Even in modern times, word symbols are learned first through their relations with objects and pictures. The reader can gain meaning from written words only insofar as these words create for him actual perceptual experiences or associations. Even the most advanced scientist depends on this connection between perception and verbal symbolism, and consistently uses visual illustration to support his use of words.

A primary principle of our theory is that artistic illustration helps define the general character of a book. The effectiveness of a book, textbook or otherwise, depends to a great extent on the reader's recognition of its unique individuality. Dictionaries and encyclopedias have their place, but most good books are not just collections of facts. They are organized symbolic systems, which reflect the significant relationships of events in nature. Visual art can sharpen the reader's awareness of a book's character by emphasizing vital meanings, pointing up certain values, and in general reflecting the author's attitudes toward his subject.

We have said that the motivation to read is in part perceptual motivation to explore, add to, and organize more completely the social and physical environment. The same motivation underlies artistic appreciation and artistic creation. Millions of people roam the museums of the world and intellectually roam through books for the same general purpose, to promote a more complete perceptual organization of the world at large and of their own needs and place in it.

Because of this common functional pattern of perceptual motivation in artistic appreciation and reading, verbal and artistic symbolism can interact in attracting, directing, and sustaining interest in the events and ideas of a book. According to our point of view, artistic illustrations have no substitute in providing the essential conditions for sustained perceptual motivation in reading books. They direct attention to main events, segregate important observations, program the course of thought from the general to the specific or from the simple to the complex, and produce the environmental variations needed to hold the reader's interest over long periods of time. They provide, as it were, a natural, deep, organic, nonverbal base for verbal symbolism in writing.

Our theory also assumes a reinforcing effect of the artistic display on symbolic learning. The visual art can be used to confirm tentative ideas and perceptions derived from the reading material. This reinforcing effect serves to enhance understanding of the verbal symbols, and to improve retention of what is read. The artistic illustration acts as a goal in relation to the correlated passages in the text, and selectively increases the strength of the particular verbal ideas illustrated. The perceptual variety and richness provided by illustrations also promote learning at the symbolic level.

We have many decided notions about the way in which visual art can facilitate learning in reading. We believe there would be much better understanding of science, mathematics, and social human values if creative artistic illustration were systematically applied to books and teaching in these fields. We also feel that there would be a much wider understanding of foreign languages if all language books were illustrated by creative artistic displays. The widespread use of art in language training will promote understanding among different cultures. Art is not only ageless, it is also a universal form of language.

Our perceptual organization theory of reading finally proposes that artistic symbolism stimulates and implements creative thinking in the reader. Artistic illustrations provide a nonverbal base of communication which enriches insight into the meaning of written words, much as gesture and emotional expression add to understanding of spoken language. This interaction of the verbal and nonverbal material in books is based upon the correlation between equivalent forms of symbolism in art and in verbal expression. Specifically, representative, abstract, and impressionistic symbolism in artistic expression can be used most effectively with concrete, abstract, and emotional or motivational patterns of literary expression. This correlation enhances the reader's insight into the subjects thus illustrated, and increases the probability of his developing new relationships and ideas in thought. Artistic illustrations can be created to interact effectively with any form or level of verbal symbolism.

The theory of learning underlying the principles of book design outlined here is in contrast to doctrines of specific-response reinforcement and conditioning, which have become so prominent in modern psychology. The main notion here is that man learns some few things through specific-response reinforcement, but that generally, and especially in reading, he has risen above this level of motivation and organization. We do not depreciate reinforcement as a factor in learning. We say that, in man, reinforcement is organized on a broader base and in terms of many more dimensions than the base and dimensions of the specific reflex response. We say that the primary dimensions of reinforcement in human learning, and especially in verbal and symbol learning, are related to perceptually organized motion, to perceptually structured emotion and need, and to the general activities of motivation in aural or visual recognition, discrimination, classification, and artistic representation. The phenomena of the picture book, of music, radio, motion picture, television, the various forms of human art, and of the development of language itself all define the significance of this point of view. Artistic visual design is tied in with reading on both the side of motivation and reinforcement, as we have shown. Artistic representation is the basic transitional process between manipulation and knowledge of objects and the verbal symbolization of these objects. Art is a primitive age-old indispensable means of human communication, which may be degraded by picture-books and poor television, but which will always have a vital role in human learning and education. The full significance of artistic design is yet to be discovered in modern education.

The theory of textbook design presented here, and the materials of the textbook and workbook evolved from this theory, may be employed as the basis of research on the nature and effectiveness of textbooks in teaching.

One of the main predictions of our theory is that students will react to an artistically illustrated textbook as being better organized than a book based largely on verbal dialectic and logical discussion. A systematic comparison has been made of an artistically illustrated book and an equivalent scientific textbook on human behavior consisting of a rigorous logical approach to the subject. Over 80 percent of 150 students in a beginning class in psychology in one of the outstanding educational institutions of the country reacted to the illustrated textbook as a well organized book. The same reaction to the other one as a well organized book was considerably less.

We do not predict from the theory stated here that verbal memory and comprehension are increased on a short-term basis by artistic illustration. Experimental tests have shown that immediate verbal comprehension with and without illustrations is not significantly different. The prediction is made, however, that perceptual memory of the contents of a book is enhanced by artistic illustrations. We are at present developing electronic teaching machines to test some of these predictions about the relative comprehension and memory value of illustrated and purely written material.

The theory of artistic visualization of books described here may be extended to other educational media, such as the design of advertisements, industrial training books, and teaching devices. We apply the specific principles described here to the design and development of automated lecturing devices, made up from tape recorders and tape-recorder controlled filmstrip and slide projection devices. We have termed them "Audiovisumatic Teaching Devices." Besides presenting material to be learned, these training machines also ask the student questions in aural or visual form, which must be answered by punching an answer sheet. The correct response to the answer sheet controls further questions presented by the machine.

The audiovisumatic teaching methods represent a "new dimension" of visualization of lecturing and tutoring. These machines achieve for lecturing what artistic illustration achieves for book design, that is, controlled integrated visualization that may be varied in artistic function. They also open up a new approach to study and the development of aural-visual "workbooks" for the student's individual use. The integrated artistic visualization of material with both written and oral speech in teaching is now within the reach of every teacher.

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PICTORIAL ILLUSTRATIONS

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The investigation described in this article is a portion of a larger evaluation project resulting from a program need felt by the Pan American Union's Latin American Fundamental Education Press in Washington, D.C. In cooperation with UNESCO, the press in 1951 began producing supplementary reading materials for newly literate adults in Latin America. The responsibility of the press was great--its educational materials were to be used in agricultural and health extension work, literacy programs, and many other public-service projects in Latin America. Although a few charts, filmstrips and other audio-visual aids were, and still are, produced by the press on an experimental basis, the major portion of the program consisted of a series of highly illustrated, simply written booklets in Spanish on subjects of immediate value and practical interest to the average rural Latin American.

In planning these booklets, the illustrations were designed to help tell the story as well as interest the intended reader. A full-page captioned illustration was used for each page of text material. These illustrations appeared throughout each booklet on the left-hand page with text on the right-hand page. The text on each page was usually limited to one or two basic ideas. The facing illustrations were planned to help the reader interpret the text.

For the most part, information was couched in story form, as in the case of a booklet on soil conservation which told the story of a typical farmer who loses his farm because of drop of productivity resulting from erosion. In all cases, the story was written with some sensitivity by well-known Latin American writers, and only experienced book illustrators were used in preparing the illustrations. The illustrators worked closely with the editorial staff in developing the overall story unit.

Before large editions were printed for distribution, the author was asked to direct an extensive evaluation study in Costa Rica and Mexico to test the overall communication potential of the first 12 book-

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Reprinted from "Communication Potential of Pictorial Illustrations," AV Communication Review, IV (Winter 1956), 31-46.

lets of the press. Because of the extensive use of illustrative material, it was decided that one of the aims of the investigation would be to evaluate the usefulness of the pictorial illustration in adding to the effectiveness of the booklets.

An aspect of the overall study which will not be described here in detail showed that illustrations usually, though not always, helped the reader get more information out of the booklets used in the study. In the case of 8 out of 11 booklets tested, an average of 66 percent more information was recalled by those reading the booklets with illustrations as compared to those reading the same booklets without illustrations (2, p. 135). This conclusion was based on the results of recall and association tests given to the 102 adults in rural and urban areas of Costa Rica and Mexico after they had read one of the 11 booklets used in this phase of the investigation. Approximately half of the test subjects read the text material without accompanying illustrations and the other half read the appropriate booklet complete with one illustration per page.[1]

As in previous studies on children's comprehension of illustrative materials (1, p. 34-35; 3, p. 44-45) the additional effectiveness of illustrations was not demonstrated in the cases of all booklets used in the investigation. The figures of the remaining three of the 11 booklets showed that an average of 26 percent more information was remembered by adults reading the booklets without illustrations than by those reading them with the appropriate illustrations.

A careful examination of the three booklets which negated our majority results led us to propose two possible explanations:

1. Two of the three booklets used an illustrative style which we classified as "woodcut." The style violated perspective and was not clear-cut in terms of items and actions depicted. If attempted, for the most part, to be "arty" but not necessarily communicative. This led us to believe that illustrative material should be realistic, not violating perspective, and that such material should be carefully planned so that each drawing communicates one or two basic ideas. If the illustrative material does not communicate a clear-cut idea, it will not help clarify the accompanying text.

2. In the case of the third booklet, clear-cut, realistic line drawings were used, but the subject was a relatively technical one--that of how a typical consumer cooperative operates. This booklet, in another phase of the evaluation study, was among the three which received poorest rating in terms of information remembered by adults when reading it. Thus, there may be certain complex procedural information which is not always appreciably clarified by the use of illustrations, no matter how clear the illustrative style.

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[1] Both with and without illustration texts used exactly the same type face and format.

Available facilities did not make it possible to follow up explanation number two with further research. However, assuming comparable editorial competency and expert selection of content to be illustrated, it was reasonable to assume that we could investigate internal factors of illustration design and structure that affect communication potential of pictorial material. We therefore formulated a further study to isolate factors which affect the clarity of content and purpose of the illustrations themselves, irrespective of the text which they accompany.

Assumptions and Test Procedure

It was assumed that if representative beginning adult readers in Latin America could correctly and completely interpret a particular illustration of those used in our booklets then this illustration would add to the communication potential of the booklet of which the illustration was a part. Correct and complete interpretation consisted of generally describing the scene illustrated, including both the principal action and objects depicted, as it was intended by the artist. The access in the Washington office of the artists who drew the illustrations facilitated establishment of this criterion of correctness and completeness.

It was further assumed that the research staff could make generalizations as to probable factors of illustrative content and design which assist or block complete and correct interpretation. This assumption was made on the basis of comparative evaluation of the interpretive responses.

The test procedures consisted of having individual respondents examine each of a series of illustrations, telling what he or she saw in the drawing. Annotation sheets, with detailed instructions to remind the examiner of the procedure, were assembled in large portfolio type folders, along with a clip and backing board to facilitate the administering of the tests under adverse conditions.

Examiners were cautioned not to ask leading questions. After establishing rapport with the examinees, the examiner was to ask only what was seen and what was happening in the illustration. The test subject could be prompted only by the question, "Anything else?"

The examiner was instructed to note the exact responses of the test subjects in telegraphic form, eliminating only structural words which would be understood when tabulating the responses.

Materials of the Study

The interpretation study used the 252 full-page (approximately 5 3/8" by 8¼") illustrations originally appearing in 12 fundamental education booklets of the Latin American Fundamental Education Press. These artists had prepared the illustrations and three styles could be identified. The three types of illustrations may be classified as (a) realistic drawings (143 of this type were used in the study); (b) woodcut (90 of this type were used); and (c) stylized (19 of this type were used).

Of the 252 illustrations, 17 were black and white, and 81 made use of one added color (a brownish orange in 44 illustrations and a green in 37 illustrations).

The 252 illustrations were removed from the text and mounted separately in loose leaf notebooks. Each series of illustrations from a particular booklet was mounted in a separate notebook. In addition, two sets of each series were mounted, one set including the illustrations with original captions and the other set consisting of the illustrations with no captions. Interpretive responses as evoked by the _with caption_ series could thus be compared to those of the _without_ caption series.

Respondents and Test Areas

The testing took place in three areas of Mexico and three areas of Costa Rica. These two countries were chosen primarily because they represented the extremes in Latin America in terms of percentage of adult illiteracy, Costa Rica being one of the most literate and Mexico one of the least literate of the countries. Official cooperation was extended by various intergovernmental and private organizations as well as the governments of both countries.

Two rural areas and one urban center of each country were used as test locations. Examiners were recruited from adult educators and extensionists who were known to the people who would be tested, and the examiners were trained for several days before administering tests.

Because of the various other activities in the overall evaluation project, and because of the time necessary to give the illustration tests, a total of only 98 persons were used in the illustration research. However, these 98 persons were fairly representative of the six test areas. Approximately 70 percent of the respondents were from farm families, 65 percent of the respondents being male and 35 percent female. In Costa Rica, the respondents of the overall study reported an average of 4.3 years of schooling, while those in Mexico reported an average of 1.8 years. The majority of respondents were in the "young adult" age group, _i.e._, 15 years through 30 years of age. A total of 2138 separate illustrations were examined by the test subjects, for a mean average of 8.5 interpretations for each of the 252 illustrations used in the study.

Analysis of Data

The 2138 illustration interpretations of the test individuals were tabulated directly onto master illustrations. Items that were described in an interpretation were checked on the actual illustration. Action or description was noted at the side.

The results were a series of 252 master illustrations graphically showing what 98 rural Latin Americans saw in the drawings they interpreted. The graphic evidence as visible on the master illustrations was examined with the following questions in mind: (a) What objects were seen and not seen by the test subjects? (b) What action was described and what was not? (c) What portion of the illustration seemed to attract sufficient attention to be described in detail? (d) Was there any description missing? (e) Was there any uniformity of response which would indicate that the test subjects consistently examined the illustration in a particular eye-movement pattern? (f) Did the illustrations using color elicit any responses which would indicate that the color affected interpretation either favorably or adversely?

Generalizations

As we thus summarized the interpretation data, we were able to tentatively proposed certain generalizations:

I. Past experience of the viewer, as would be expected, largely determines how he will interpret individual objects in the illustration.

The interpretive errors made in describing Figure 1 are illustrative of a large portion of misinterpretations evident throughout the study. The large building in the background was associated with buildings of like magnitude with which the viewers were familiar. Thus, we tabulated the range of interpretations from "palace" to "hospital."

Figures 2 and 3 illustrate a somewhat more subtle point, mainly that the artist must be very clear in his depiction of physical surroundings, not assuming that the viewer's experience will enable him to identify such items as a river or to distinguish between indoors and outdoors. The action of pushing along a barge with a pole is not familiar to many Latin Americans, thus they would not identify the enclosure as a barge (Figure 2). Similarly, although the crosses on the hill and the typical outdoor platform would immediately identify the outdoor scene of the Gettysburg Address for most United States nationals, such clues would not touch on the experience of Latin Americans. Thus, Figure 3 generally elicited interpretations which placed the action indoors which is the most usual place for a speech.

In interpreting Figure 4, the viewers clearly showed that they tend to ignore items in an illustration which are completely unfamiliar. Although 13 out of 14 viewers mentioned the serpent in the right hand (a familiar object), not one viewer thought that the object in the left hand merited a mention.

Statistical analysis of the responses showed that a series of illustrations of the life of Lincoln elicited, on the average, the largest percentage of erroneous and incomplete responses of any of the drawings. This series was the only one done by a United States artist, and the implications may be two-fold: (a) that the artist was not familiar with

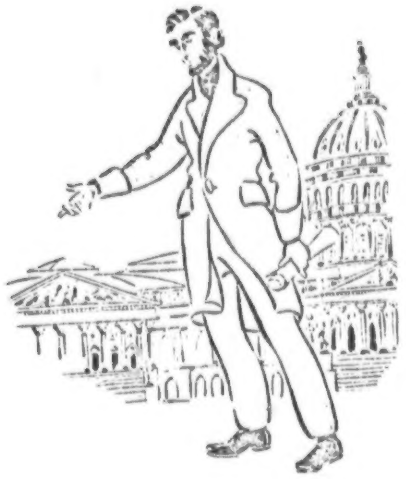

FIGURE 1

Of five persons, one person described the Capitol as "castle," two saw it as a "palace," one saw it as a "hospital." The "hospital" idea may have been a carry-over from a previous illustration in the same test, which depicted Lincoln's bedridden mother.

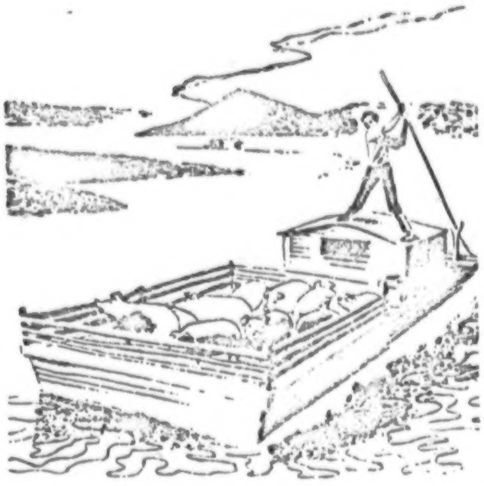

FIGURE 2

Of three persons seeing the illustration without the caption, two thought that the enclosure was a "pig-pen"; even one of the two seeing the illustration with the caption, "He Traveled on the Mississippi River," did not get the idea that the enclosure is a barge. No one called the animals "pigs."

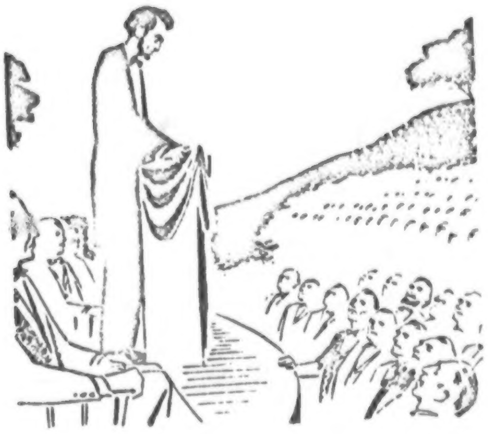

FIGURE 3

Of five persons, no one considered this scene as taking place outdoors. One called it a "class," another called it a "lecture hall." No one noticed the crosses in the background.

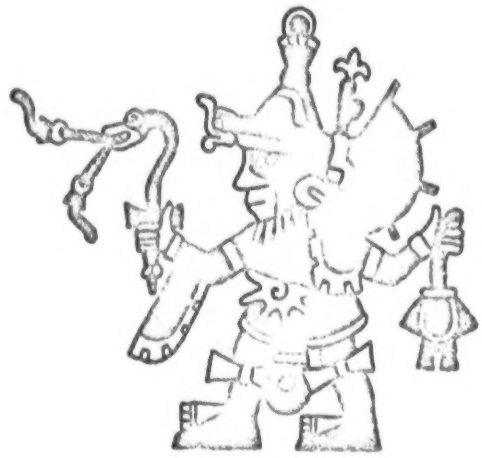

FIGURE 4

Of 15 persons, all mentioned the figure as the first item. Fourteen of the 15 mentioned the "serpent" in the right hand, in that order, after mentioning the figure. No one mentioned the item in the left hand.

the experience pattern of the audience which was to view the illustration and/or (b) that the subject matter at hand was so unfamiliar to most of the respondents that errors and omissions were imminent.

II. Past experience affects value judgments even to a greater degree than interpretation of concrete items.

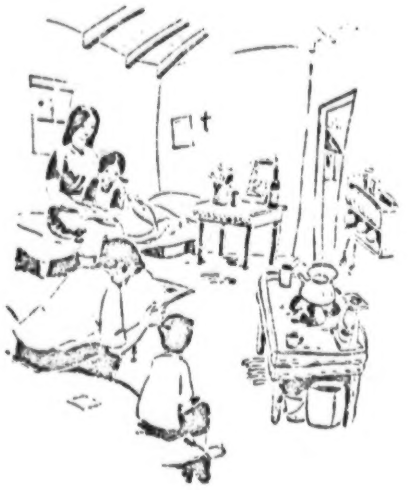

FIGURE 5

Most were very detailed in describing scene. However, only one person out of nine who saw the illustration mentioned that it is a "small" room, and this one case was probably influenced by the caption. No other person so described room or mentioned that it is in any way undesirable.

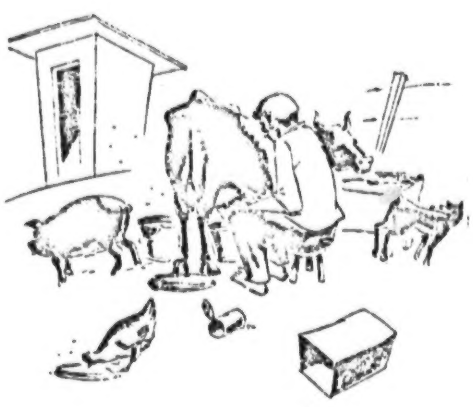

FIGURE 6

Of nine persons seeing the illustration without the caption, no one mentioned that the yard was dirty or ill kept. Of five seeing the illustration with the caption, "A Dirty Yard," two did not mention that the farmyard looked dirty.

A social worker might feel that the room depicted in Figure 5 is small and cramped. Similarly, an agricultural extensionist might feel that the farmyard of Figure 6 is dirty and poorly kept. For rural Latin Americans, however, the room and the farmyard as depicted are more or less what is expected, and if such people read a story which is accompanied by such drawings, it is conceivable that the illustrations would have a negative rather than positive communication effect.[2] If a room is to look small and cramped, it may be that the artist must make it look even more so than the smallest and cramped quarters with which the viewer is likely to be familiar. Similarly, the farmyard might well be one stage more poorly kept than those with which the viewer will be familiar.

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[2] In research partially motivated by the study described here, the UNESCO Group Training Scheme at Mysore, India, found that the presence or absence of people depicted in a village scene determined whether or not the village would be described as "poor." Two illustrations were drawn, one according to the caption, to illustrate a "poor" village and the other to illustrate a "very poor" village. The "very poor" village showed poorly dressed people carrying on their daily activities in the street, while the "poor" village showed very few people. The viewers felt that the village with the large number of people must be more prosperous, irrespective of the dress. Here, of course, we find viewers making value judgments on the basis of the one clear-cut criterion of "poorness" which they immediately recognize in the two scenes depicted. Physical cleanliness of architectural superiority mean less to this audience than the presence or absence of bustling crowds (4, p. 4).

In correspondence with the author, John Burton, Medical Director of the Central Council of Health Education, London, raises a pedagogical question in reference to the possible use of exaggeration in such illustrations. Dr. Burton suggests that if exaggeration is overdone, the viewer will assume that the information does not apply to him, since his situation is not nearly so poor. This may occasionally be the case, but we feel that clear comprehension of the implications suggested is a first priority, since readers usually first make generalizations which they later apply to their own situation as principles, and not as specifics.

III. Viewers make generalizations on the basis of a limited number of specific details.

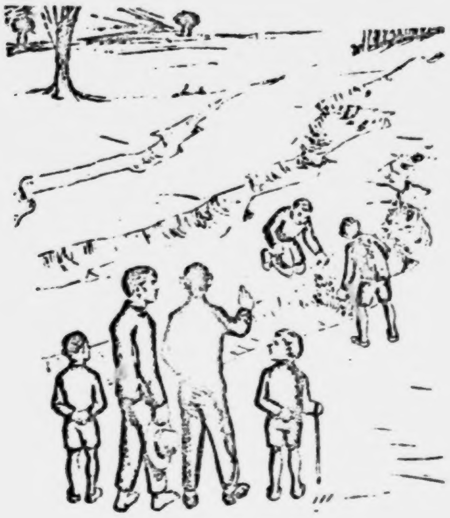

FIGURE 7

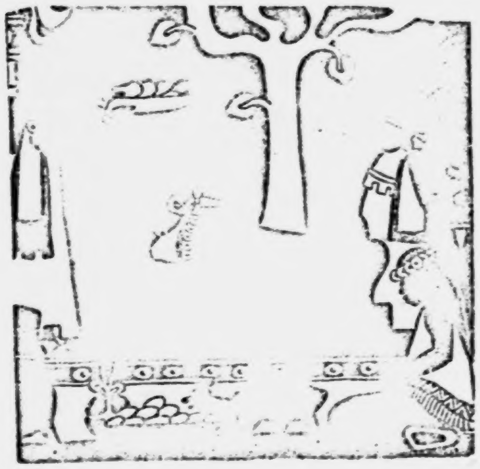

FIGURE 8

Of seven persons, three of these seeing the illustration with caption, no one got the idea of damming ruts or gulleys. Among interpretations are the following: "removing dirt"; "planting trees"; "sowing"; "teacher working children"; "looking"; "no idea." Most respondents mentioned figures in the foreground; figures in background were not emphasized in the responses.

Of 14 respondents, all mentioned the figure of the king first. Many did not mention the other figures, Emphasis was on the figures to the right, after mention of the king, by three out of five seeing the illustration with the caption.

The figures in the foreground of Figure 7 misplace the emphasis which should be placed on the figures in the background. Since the illustration is meant to show the process of damming up ruts, most other details not necessary to visually describe this action should be eliminated. Otherwise, added detail may motivate an interpretation that will not be compatible with the purpose of the illustration.

Figure 8 contains some extraneous detail, but all action faces the figure on the platform. Thus, attention is attracted here, and in most cases the figure on the deathbed is mentioned first, correctly identified as very sick or dead.

Figures 9 and 10 dramatically illustrate the value of well-placed

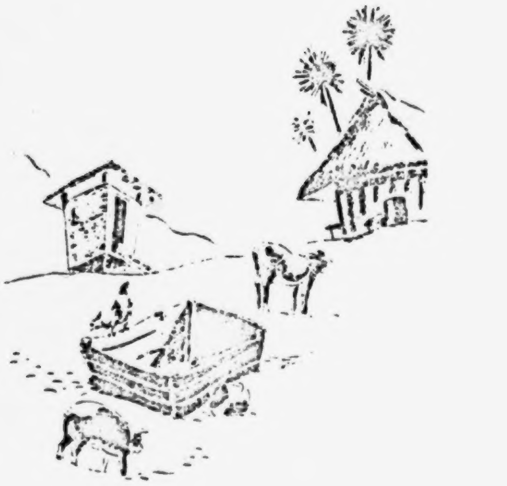

FIGURE 9

No one viewing this illustration responded that the square enclosure is a well.

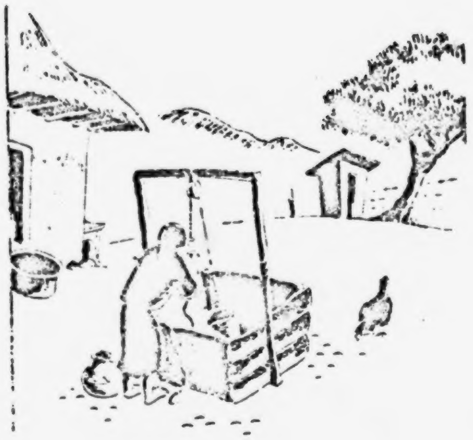

FIGURE 10

All persons tested mentioned the well, as compared with lack of such response to Figure 9.

visual cues. No viewers interpreted the enclosure as a well in Figure 9, while the addition of a rope and bucket ensured 100 percent correct identification of the well.

Visual cues, of course, must vary according to the cultural background of the intended audience. In the United States, for instance, a milk bottle will universally be identified, while in many other countries it would be unknown.

IV. People in rural areas of Latin America are extremely literal in their interpretation of depicted action.

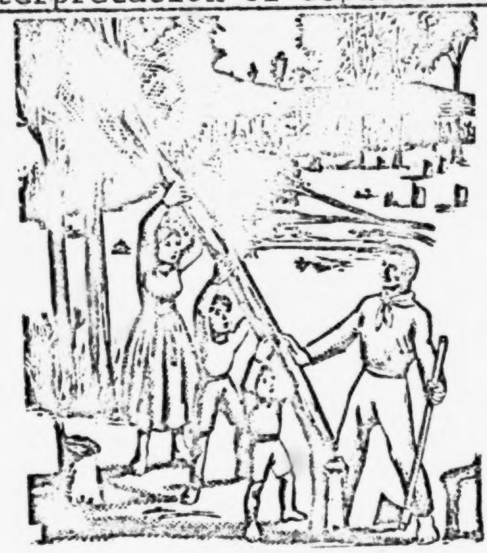

FIGURE 11

Of seven viewers, three mentioned danger in cutting tree so that it falls toward the family.

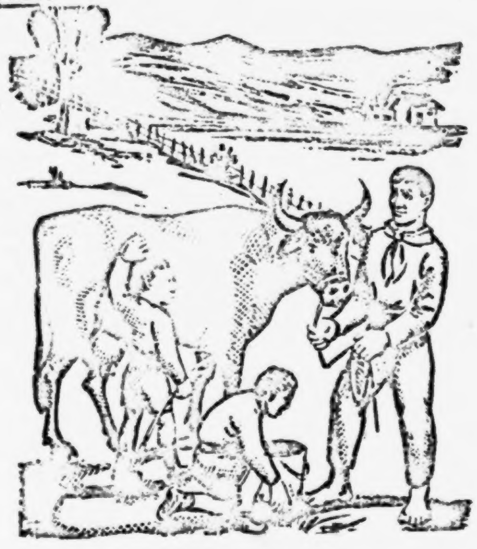

FIGURE 12

Of seven people seeing the illustration, three thought that something was wrong with the leg of the cow; one thought that the boy was cutting the leg off.

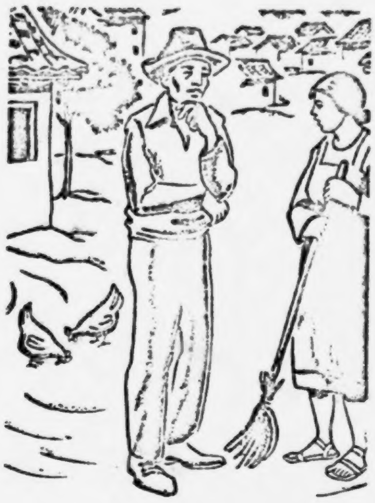

FIGURE 13

This portion of the illustration elicited comments by viewers as to the odd color of the broom and the chickens (green).

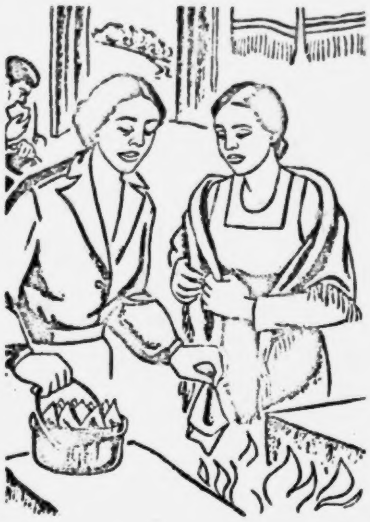

FIGURE 14

Of the four people viewing the illustration, three missed the idea of fire shown in this section of the drawing. Comments indicated that the green color of the fire caused the confusion.

Without doubt, more sophisticated audiences would not have difficulty in correctly interpreting Figures 11 and 12. However, rural Latin Americans made grotesque misinterpretations. That the viewers thought the farmer is trying to kill his family in Figure 11 shows lack of ability to interpret symbolism in drawings.[3] Similarly, the "cutting off cow's leg" interpretation of Figure 12 shows extremely literal interpretation of depicted action.

V. The use of color in illustrative material adds to the communication value of the illustration if the color adds to the realism; color detracts if it is used unrealistically.

The study produced, for the most part, negative data to substantiate the above generalizations. In Figure 3, for instance, the test drawing used a brownish wash which colored the one tree in the background. This coloring did not communicate the concept of a tree, since all viewers interpreted the action as taking place indoors.

Similarly, in Figure 13, a green wash colored the chickens and the broom causing considerable wonderment on the part of some viewers. The color thereby detracted rather than added to the communication potential of the illustration. In Figure 14, the use of a green wash which colored, among other details, the fire, caused more disastrous effects. No one responded with the idea of something (actually, sputum bags) being burned.

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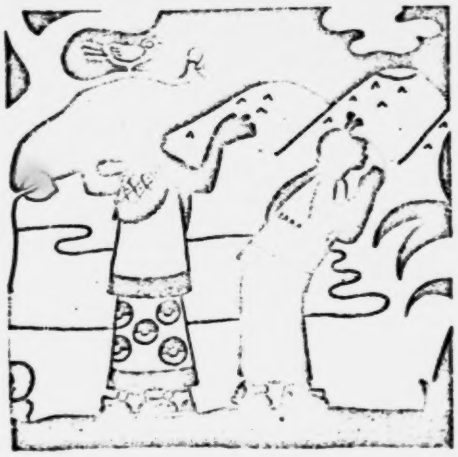
[3] It may have been that the artist who drew Figure 11 was grossly misinformed as to the advisability of the farmer's family helping him by standing under a falling tree. The artist in question, however, hedged by saying that she was symbolically depicting family cooperation.

These undesirable interpretations lead us to believe that color, when used indiscriminately, can do damage. Color must be used functionally. If the tree had been colored green, the broom and chickens brown, and the fire red, the color would have been an added clue to help the reader correctly interpret and not a stumbling block to correct interpretation.

Other portions of the evaluation study showed that color usually added to the interest potential of the booklets. Single colors were used as decorative motifs, illustration borders, and in other such ways, in several booklets and appeared to markedly distinguish such books from those which used no color. Therefore, it may be that if less than full realistic color can be used in the illustration, then the color should be used elsewhere than in the illustration itself. Such color, of course, should be used to highlight portions of the text or to draw attention to the illustrative material, and in no case should be used promiscuously in a way that would detract from the message.

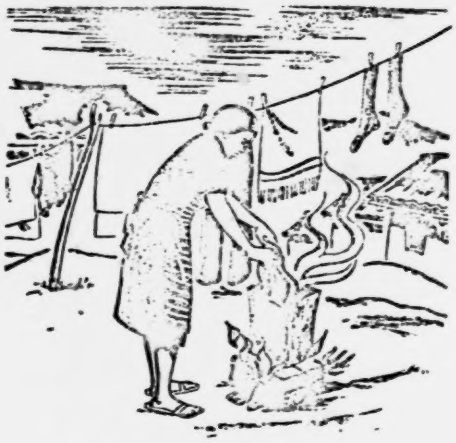
VI. Captions help viewers to correctly interpret the illustration.



LA ESTRELLA DESAPARECIÓ

FIGURE 15

"The star disappeared." The majority of those viewing the illustration with the caption mentioned the reason for the frightened attitude of the Indians.



HIERVE LA ROPA

FIGURE 16

"She boils the clothes." The three persons seeing the illustration with the caption mentioned the "boiling" of the clothes. Those seeing the illustration without the caption mentioned only "washing," with the exception of one person who saw "plucking the feathers of a chicken."

Of the 2138 illustration interpretations tabulated, 69 percent of the illustration-with-caption responses were complete and correct, while only 56 percent of the without-caption responses were so judged. Thus, there were proportionately about six complete and correct with-caption responses for every five complete and correct without-caption responses.

More general comparative observation of the responses motivated by the with-caption illustrations indicates that captions serve to:

1. Describe relative conditions which are difficult to depict pictorially (dirt, poverty, health)

2. Name persons, places, and objects

3. Relate the action of the illustration with that which has gone on previously or that which will follow (Figure 15)

4. Specify what people in the illustration are doing (when action is vague or not familiar), thinking or saying (Figure 16)

5. Draw attention to certain portions of the illustration.

In essence the quality of the responses of those viewing the illustrations with captions as compared to responses of those seeing the illustrations alone indicated that, as would be expected, visual materials are severely limited to their communication potential when used without accompanying verbal material. Captions and text serve to generalize, modify, relate, and extend the meaning suggested in the visual material. Pictures help put meaning into the words used, but the illustrations can not take the place of the words. The words, being abstractions, have skimmed off something common from thousands of concrete experiences and are therefore much more efficient communication units, especially if illustrative material assists the reader to relate the word value to his own experiential background.

In educational reading materials, the text, the illustrations, and the captions each serve a unique function in the communication process. The text offers the continuity, while the illustration orients and emphasizes. The caption, in turn, clarifies the illustration so that there is no question as to the portion of the text to which it refers and so that the visual cues are not misconstrued.

Summary

As readability studies have investigated factors which influence the reading difficulty of verbal text, so this study has been a beginning attempt to isolate the factors which influence the communication potential of illustrative material. It is interesting to note that as readability researchers have found a correlational relationship between idea density (number of different ideas per number of running words) and reading difficulty, so this study has shown an inverse relationship between complexity of an illustration and its effectiveness in communicating clearly. Similarly, as readability studies show that we must use words that are familiar to the reader, so we must present visual concepts in terms of the background of experience of the intended viewer. And as in constructing effective textual material we must organize our material logically, eliminating the unnecessary, so we must simplify the design of illustration, taking care, of course, not to lose the essential.

More specifically, implications of the present study may be listed as follows:

1. An illustration as such has no educative value, and may even be a detracting influence, if the drawing content has not been presented in terms of the past experience of the intended audience. We may assume the "past experience" consideration to be especially significant for those who publish educational materials such as those used in fundamental education campaigns. Such materials deal largely with environmental subjects, the component details of which are often more familiar to the reader than to the artist who constructs the pictorial material. Similarly, when preparing material for children or for foreign audiences, the artist must attempt to construct the pictorial image in terms of an audience whose background of experience is much more limited and/or couched in a different cultural setting than his own.

The obvious "past experience" consideration does not mean to imply that visual material which depicts actions or objects unfamiliar to the viewer cannot be used. In such cases, however, care must be taken to use the visual construction in careful context with other illustrative and textual material, much in the same manner as a new word is introduced contextually in foreign language "direct method" texts. Meaning for unfamiliar visual symbols must be developed in the mind of the viewer much as meaning of verbal symbols must be developed.

2. Illustrations that are intended to communicate specific ideas will be most effective if (a) the number of objects that must be seen to correctly interpret the illustration are kept to a minimum, (b) the number of separate actions necessary to correctly interpret the basic message of the illustration are kept to a minimum, and (c) all objects and inferred actions are realistically portrayed and not open to dual interpretation or secondary inference.

These three criteria are inferred from study data which indicates that respondents made generalizations on the basis of a limited number of specific details, with unnecessary details serving only to confuse, and on the responses which showed that respondents are very literal in their interpretation of depicted objects and actions. The criterion of realism refers only to the need to portray actions and objects clearly, without violation of perspective and without fuzziness of detail. Photographic realism is not advocated, since such representation usually include unnecessary detail which can obscure the area of emphasis.

3. Color in illustrative material adds to the interest potential of the drawings. However, unless used realistically and functionally, color may detract from the communication potential of the drawings. This is especially so in the case of drawings which utilize only one color or two colors in addition to black and white. In most cases where full color realism cannot be achieved, it may be wise to limit the use of color to border and decorative motifs.

4. Captions, in general, usually serve to add information which is difficult to depict pictorially. Captions, however, should usually not be used to explain the illustration, but rather to generalize, modify, relate and extend the meaning of the illustration.

In some educational materials, illustrations are used to establish setting and create interest, with no inherent communication value intended. The most judicious use of the pictorial illustration, however, would seem to be that in which it is so used, in conjunction with the text, that the resulting whole is a communication package which surpasses both the interest and communication potential of either the text or the pictorial material alone. Such a communication package would be a middle road between comic books on the one hand and traditional textbooks, with illustrations added by the publisher often as an afterthought, on the other.

The present study, of course, has been extremely limited in that the audience, the pictorial illustrations, and the text material involved were all of a special and somewhat unique nature. It is hoped that similar studies be extended to examine the communication potential of illustrative material used with verbal texts of more diverse content than those studied here, and designed for interpretation by others of the many possible audiences.

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GRAPHIC PRESENTATION

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Richard D. Powers
Bryant E. Kearl

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The effectiveness of various forms or methods of presenting statistical information to the public is still very much an unexplored field. This is surprising in view of the relevance of the subject to writers and editors who face the task of putting masses of numerical data into readable form for effective use by the general reader. To date only three pertinent studies (Washburne, 12; Carter, 2; Vernon, 10) appear in the literature.

Washburne tested 15 textual, tabular, and graphic forms on 300 sixth, eighth, and ninth graders. He concluded that form or method of presentation is a significant factor in the comprehension of statistical information and that the table is decidedly better than a line graph in helping the reader recall specific amounts.

Carter presented three different tables and four graphs to 68 male science students to find out a method of tabular or graphic presentation which would be superior for all types of problems. His findings favored long and detailed tables over short and simple tables, and tables over graphs.

Vernon studied the value of graphic material with written text and concluded that graphs do not necessarily help in promoting better understanding of the argument in the written text.

Differences in subject matter and in nature of test groups make it difficult to apply these findings as generally as one might wish. Not one of these three researchers could, on the basis of his findings, establish a rank order for general effectiveness for tables, graphs, text, and tables and graphs reinforced with text.

Reprinted from "The Presentation of Statistical Information," AV Communication Review, XI (May-June 1963), 32-39.

The study reported here was thus planned and conducted to obtain findings of more widespread and precise applicability. It aimed at accomplishing this by using a better experimental design, more precise statistical methods and techniques of analyses, standardized tables and graphs of better design, a greater variety in background of test subjects, and a larger number of subjects than in the preceding investigations. It sought, specifically, to answer questions such as the following:

1. By reducing a statistical table to a minimum number of elements particularly to be communicated, is better comprehension obtained than with a longer and more detailed table?

2. Does a well-designed graph communicate better than a table?

3. How does text by itself compare with tables or graphs in effectiveness of communication of statistical data?

4. Is communication improved when tables or graphs are used to reinforce text by repeating the same information given in the text?

The study also sought to find out which presentation method is best for specific interpretive operations--choosing a specific value from among several values, comparing amounts, comparing proportions, and the like.

The Study Design

Four different kinds of fictitious but realistic information dealing with agricultural items were presented, and seven different methods of conveying numerical information were employed. These methods were--

1. A long, detailed table. This table carried information which was required for the answering of the test questions asked. It has been suggested that additional information of this kind in a table would make it difficult for the reader to comprehend a specific intended piece of information. Such a table is sometimes used when the writer is not certain which of the many pieces of data different readers will read, since it can provide a great deal of information in one presentation.

2. A short, simple table. Detail not required for the test questions was eliminated from the long, detailed table to produce this simplified form. This is comparable to what a writer might do in editing a long table down to the information he considered essential to communicate.

3. A well-designed horizontal bar graph. This graph provided the same information as the short table did, with the identification and numerical facts specifically stated on the bars themselves. Previous studies (3,4,6) had shown that this practice is more effective than designing graphs with grids or keys.

4. A four- to six-paragraph text. A study (13) about 40 years ago concluded that text is effective only when one or two facts are presented. The text used in the present experiment presented the same information as did the short tables and the graphs.

5. A long, detailed table, reinforced with the four- to six-paragraph text (Forms 1 and 4 combined). It has been suggested that reinforcing such a table with text would make statistical material easier for the reader to understand.

6. A short, simple table reinforced with the four- to six-paragraph text (Forms 2 and 4 combined). It has likewise been suggested that supporting this kind of a table with textual explanation would result in better reader comprehension.

7. A well-designed horizontal grouped bar graph reinforced with the four- to six-paragraph text (Forms 3 and 4 combined). Some writers (1,8,13) have argued that adding visual interest to textual explanation will improve comprehension.

In each of the four experiments conducted, four of these presentation methods were employed. The 1080 test subjects included high school students in Dane County, Wisconsin, students in the Agricultural College of the University of the Philippines, Laguna, Philippines, and adult women who were members of homemakers clubs in Dane County, Wisconsin.

Thus there were four experimental variations, and for each experimental variation there were four presentation methods and four subgroups of test subjects combined in 16 ways. To this arrangement, another factor or treatment was added to eliminate the possible effect of the order in which the test subjects read the information. The experimental design known as a Graeco-Latin square was used. It involves four treatment classifications with the same number of levels of each, with each treatment in any classification combined once and only once with each treatment in each classification.

This design made it possible to study the main objective, relative effectiveness of the seven methods of statistical presentation, and at the same time balance out possible differences due to subject matter, subgroups of test subjects, and order of presentation.

Efforts were made to keep the presentation methods--horizontal grouped bar graph; short, simple table; long, detailed table; text--comparable in difficulty. Each presentation method was accompanied by seven standardized questions which required test subjects to perform similar interpretations of the information presented.

Analysis

The scores obtained by each test subject in each group were anal-

TABLE 1--Summary of Analyses of Variance, Grouped Data,* for Four Experimental Variations

Source of Variance	EXPERIMENTAL VARIATION																			
	Sums of Squares				*Degrees of Freedom*				*Mean Squares*				*F-Ratio*				*Significance*			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Method	6693.12	475.50	358.87	639.00	51	15	12	12	131.24	31.70	29.90	53.25	2.32	3.38	19.41	6.66	.01	.01	.01	.01
Subgroup	2011.29	224.40	40.37	129.84	51	15	12	12	39.44	14.96	3.36	10.82	1.71	1.05	1.71	1.35	NS	NS	NS	NS
Order	593.57	96.90	21.99	31.68	51	15	12	12	11.64	6.46	1.83	2.64	.21	.69	1.18	1.00	NS	NS	NS	NS
Subject	827.52	135.60	18.99	25.32	51	15	12	12	16.22	9.04	1.58	2.11	.29	.96	1.02	.80	NS	NS	NS	NS
Latin Sq. Error	652.14	96.90	24.26	49.20	51	15	12	12	12.78	6.46	2.02	4.10	.23	.69	1.31	.49	NS	NS	NS	NS
Error w/in cells	10023.64	1364.16	193.84	575.28	436	96	68	72	22.99	14.21	2.85	7.99								
Error	73823.76	2701.44	314.30	568.08	1308	288	204	216	56.44	9.38	1.54	2.63								
Total	94624.84	5094.90	972.62	2018.40	1999	459	332	348												

* Experimental variation 1, 11 high schools and 6 homemakers clubs; variation 2, 5 high schools; variations 3 and 4, 2 high schools and 2 homemakers clubs each.

yzed by analysis of variance to identify the effects of each of the variables studied and controlled.

The mean scores for these same groups for the various presentation methods were analyzed by Duncan's new multiple-range tests to determine how the seven methods ranked in effectiveness.

The analyses of variance showed that method of presentation was a significant factor in learning the statistical information presented. In 36 of the 39 groups tested, differences were significant at the 0.01 or 0.05 levels. When data for the various test groups were combined for each of the four experimental variations, differences were significant at the 0.01 level for each combined group and for each variation. Also, analyses of data from all test groups combined for all four experimental variations gave the same result. Thus, in all the analyses, method of presentation, which was the main concern of the study, showed a consistently significant difference among the experimental treatments.

Table 1 presents a summary of results of the analyses of variance. From the table, note that the analyses of variance showed the experiment to be extremely precise. Most of the variation was accounted for by the variable of form of presentation. Order of presentation and subject of presentation did not show consistently significant differences.

The multiple-range tests revealed that the seven presentation methods differed significantly from one another in effectiveness on the test subjects. Table 2 summarizes the results. The main findings follow:

TABLE 2--Mean Scores for Methods of Presentation* (Perfect score = 7)

Class or Group	*Means Arranged in Descending Order*			
Variation 1				
11 High Schools	(a) 6.41	(b) 5.86	(c) 5.54	(d) 4.89
6 Homemakers Clubs	(a) 6.17	(b) 5.40	(c) 5.02	(d) 4.58
Variation 2				
5 High Schools	(a) 6.05	(b) 5.69	(c) 5.47	(d) 4.88
Variation 3				
Mixed Group				
(H.S.)	(a) 6.71	(b) 6.25	(c) 5.85	(d) 5.35
(H.C.)	(a) 6.65	(b) 5.63	(c) 5.28	(d) 4.63
Variation 4				
Mixed Group				
(H.S.)	(a) 6.47	(b) 6.00	(c) 5.00	(d) 4.92
(H.C.)	(a) 6.81	(b) 6.12	(c) 5.31	(d) 5.27

* Variation 1: a=horizontal grouped bar graph, b=short table, c=long table, d=text.

Variation 2: a=horizontal grouped bar graph with text, b=short table with text, c=long table with text, d=text alone.

Variation 3: a=horizontal grouped bar graph with text, b=short table with text, c=horizontal grouped bar graph alone, d=long table with text.

Variation 4: a=horizontal grouped bar graph with text, b=short table with text, c=short table alone, d=long table with text.

Any two means not underscored by the same line are significantly different at the 5% level.

1. The horizontal bar graphs that were used consistently produced significantly better scores than did the long tables, short tables, or text by itself.

2. Short tables resulted in better scores than did long tables when the test groups were homemakers clubs made up of women who had had little or no recent formal training and/or experience with statistical presentation methods. No significant differences were obtained between these two methods in test groups of high school and college students whose training or experience with statistical tables was more recent.

3. Both the short tables and the long tables resulted in significantly better scores than did textual presentations by themselves.

4. Using horizontal grouped bar graphs to reinforce text gave significantly higher scores than did the use of short tables or long tables for this purpose.

5. No significant difference in scores was obtained when text was reinforced by short tables as against long tables. Both kinds of reinforcement were more effective than text alone.

6. Text reinforced with horizontal grouped bar graphs and text reinforced with short tables were both significantly better than the horizontal grouped bar graphs by themselves.

7. Horizontal grouped bar graphs, even without textual reinforcements, resulted in better scores than the long tables with textual reinforcement.

8. Short tables with textual reinforcement gave better scores than the short tables without textual reinforcement.

The percentage of correct answers was obtained for each of the seven interpretive operations for the combined groups. Results, which are summarized in Table 3, show the following:

TABLE 3--Percentage of Correct Answers to Seven Interpretive Operations by All Groups Combined in Four Presentation Methods

	PRESENTATION METHOD			
Interpretive Operation	Graph	Short Table	Long Table	Text
1	85.2	93.0	89.4	87.1
2	93.2	87.7	89.1	77.3
3	91.7	85.8	78.8	63.3
4	84.1	71.0	65.7	62.7
5	93.7	85.2	84.5	81.4
6-7	92.1	81.9	69.0	61.4

1. Choosing the largest of four values (the first interpretive operation) was extremely difficult with the horizontal grouped bar graph and much easier with the short table, long table, and text.

2. Locating an absolute value (the second interpretive operation) was consistently easiest of all operations with all four methods. For this operation, the four presentation methods ranked in the following order of effectiveness (easiest to most difficult): horizontal grouped bar graph, short table, long table, and text.

3. Deriving a total (the fifth interpretive operation) was the next easiest operation. The horizontal grouped bar graph was again more effective than the short table, long table, or test by itself.

4. Comparing proportions (the fourth interpretive operation) was consistently the most difficult. Next most difficult was interpretive operation 3 (comparing amounts), followed by operations 6 and 7 (comparing amounts and stating numerical difference). Suitability of the four presentation methods for these operations was the same (most suitable to least suitable): horizontal grouped bar graph, short table, long table, and text.

Implications

On the basis of these findings it would appear that writers, editors, and specialists in popular publications can present statistical information most effectively when text is supported by well-designed bar graphs.

Previous research on graph comprehension (3,4,6,9) has shown how important it is that such graphs be carefully designed if they are to deliver their message effectively. These studies have established that for most purposes bar graphs are easier to comprehend than either line graphs or surface charts and that horizontal and vertical bars are equally easy to comprehend. They have also stressed the importance of labeling bars or other graph elements rather than keying these elements to a code or scale at the bottom or edge of the graph.

The present study suggests that short, simple tables are better than long, detailed tables in presenting numerical data to groups not too well versed in tabular methods of statistical presentation. Short and long tables presumably may be used equally effectively to present the statistical information in publications aimed at people who have had experience in using these methods.

Under no circumstances should text be used by itself to convey important statistical data if more than a very few facts are to be presented. Unsupported text was by far the least effective method of statistical presentation used in this study. A more persuasive or appealing writing style might have altered these results, but it is unlikely that the basic conclusion would be substantially different.

From the results of this study, it would appear, however, that tables and graphs gain in effectiveness when they reinforce or are reinforced by text repeating the same information. This suggests that publication specialists can reach their readers most effectively by making generous use of graphs reinforced with text. If this alternative is not feasible, then either short or long tables reinforced with text could be used.

When textual reinforcement is not possible due to one reason or another (e.g., space limitation), graphs alone or short tables alone are good alternatives. These methods were found to be more effective than long tables with textual reinforcement, long tables without textual reinforcement, or text alone.

To summarize, writers, editors, and specialists could improve the comprehension of statistical material in their publications by using the following methods of presentation listed here in the order of their effectiveness (most effective to least effective): (a) horizontal grouped bar graph reinforced with text, (b) short and simple table reinforced with text, (c) graph without textual reinforcement, (d) short table without textual reinforcement.

Long tables--even if reinforced with text--are less effective with audiences not experienced in reading tabular material. Casting the figures into a prosaic text was the least effective of all methods tested.

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PART FOUR

MEDIA DESIGN AND PRODUCTION

LEARNING FROM VISUALS

by George L. Gropper

American Institutes for Research

Explanatory Models for Visual Instruction

Even though there are obvious qualitative differences between pictorial and verbal modes of instruction, both share a common objective. By means of either mode, the educator seeks to create a learning experience that will bring about a change in behavior. Audiovisual specialists who have theorized on how such changes might be brought about have tended to adopt one of two approaches. One group has concentrated on the qualitative differences between words and pictures and has accordingly not seen fit to adapt learning theory models, available for describing verbal learning, for interpreting learning from pictures. This group has specifically developed communications or information models to account for learning from pictures. A second group has sought to deemphasize the differences between words and pictures and to emphasize the similar roles they play in instruction. It has accordingly preached the applicability of available theories of learning to both (21). This polarization of views is similar in some respects to that occurring in such recent developments in instruction as programed learning.

As Klaus (16) point out, programing techniques tend to be either stimulus centered or response centered. The former tend to be almost exclusively concerned with the meaning, structure, or organization of stimulus materials. The latter are concerned primarily with responses and with the conditions, including the design of stimulus materials, that insure adequate response practice. The former tend to be either atheoretical or configurationist in viewpoint; the latter tend to be connectionist (S-R) in viewpoint. In the case of programmed instruction, the latter point of view, as measured by the number of adherents, tends to be dominant. In the case of audiovisual instruction, the polarization in audiovisual explanations tends to parallel that just noted, with one difference.

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The stimulus-centered (information or communication) point of view tends to dominate. Unlike the learning approach, which stresses the behavior to be changed and practice conditions for bringing about such changes, the stimulus-centered approach in audiovisual instruction tends to be primarily concerned with the design of the message.

Audiovisual research on procedural learning and on motor learning has, it is true, been interpreted by some within a behavioral, S-R framework (22,25). However, empirical research in connected-discourse subject matters presented by audiovisual means has generally been interpreted by most audiovisual specialists within the framework of an information or communications model (see [26] for a review of such research). Most theoretical discussions in the same area also have tended to be "information" or "message" based (13).

Choice of either approach to account for learning from pictures makes a difference in how research on audiovisual instruction prospers, for it dictates: (a) the kinds of explanations a model offers; (b) the issues that are considered important and therefore investigated; and (c) where it looks for its data. "Information" models lead to research on questions about the redundancy of a message; the relevance of a message; the capacity of visual and verbal channels for transmitting the message; etc. Behavioral learning theories are more apt to be concerned with the analytic and dimensional analysis of variables that promote the acquisition, retention, and transfer of specific behaviors; the effect of visual and verbal modes of stimulus presentation on the acquisition of discriminations, generalizations, or chains, which are often described as the basic processes in all learning (7); the effect these different modes might have on such varied learning tasks as problem solving, learning of concepts, acquiring perceptual-motor skills; etc. "Information" approaches tend to rely for data on end-of-instruction achievement tests. Behavioral approaches, in addition, tend to rely for data on responses made overtly, explicitly, and actively during visual presentations. Asking different questions, the two different models obviously produce and provide the practitioner with different practical answers.

It is also true that some audiovisual discussions have borrowed explanatory concepts and terminology from both an information and a behavioral framework. Thus, in a discussion of "communications" transmitted through either the audio or visual channel, such S-R learning theory considerations as generalization from learning situation to testing situation are invoked (12). Or, "response practice" or participation may be stressed (24) even though the basic model is an "information" model that has no integral principles to account for its need. What are the consequences of such eclecticism for the growth of audiovisual theory and practice?

The explanatory and predictive capabilities of a theory increase as its laws begin to encompass an increasingly larger range of phenomena. Practical problems, in turn, are more apt to be solved as theory grows and becomes more comprehensive. A resort to selective borrowing from more than one theory to account (ad hoc) for particular phenomena within audiovisual instruction, thus, is likely neither to serve the advancement of learning theory or of information theory nor to make their practical implementation more widely useful or successful.

At present, supported by considerable empirical research, behavior theory encompasses a large body of explanatory principles that can account for a broad range of behavioral changes. It is reasonable to expect that they can account for the changes that define learning from pictures. As Postman (23) has pointed out, "The process of audio-visual education does not call for the formulation of special principles; it calls for the application and elaboration of the general laws of human learning." The present study, concerned with the learning of concepts through visual (pictorial) presentations, has accordingly attempted to limit the variables chosen for study to those stemming from a behavioral model and to interpret the results observed within such a framework. The decision to take this approach is based on the premise that learning theory provides the sturdiest foundation on which to base an interpretation of "learning from pictures."

The behavioral way of looking at learning requires that the process can be treated analytically; that the responses to be shaped at any point during an audiovisual presentation (not just end-of-course performance on an achievement test) be identified specifically; that the simuli that are effectively to elicit them also be specified; and that the conditions of the pairing of stimulus and response be identified and arranged systematically so that the acquisition, retention, and transfer of the desired behavior will be facilitated. Such is the prescription of a behavioral model. One consequence of the failure to make such precise specification is the uncertainty as to what it is in our presentation that actually brings about a change in behavior. The prescription applies equally well to learning from words or from pictures.

A further practical requirement of a behavioral approach is the precise description of the behavior to be changed. This is generally referred to as a definition of objectives. Its execution is important for two reasons. A comprehensive statement of objectives is necessary in order to: (a) determine whether students actually can do what a learning experience was designed to teach them; and (b) formulate an instructional strategy for building a learning experience that will bring about desired behavioral changes.

The goals of instruction are quite varied, and while words or pictures might be suitable in one instructional strategy, they might not be in another. The goals or objectives of instruction might consist of (according to one taxonomy of behavioral objectives [4]): (a) identifications; (b) knowledge of principles; (c) following procedures; (d) making decisions; or (e) performing skilled perceptual-motor acts. If a picture is truly worth a thousand words, is this value likely to be invariant for all these types of learning? Even within any given type of learning task, is the value of pictures likely to be invariant? Thus, research on learning from pictures, as well as practical applications of audiovisual principles, must pay due analytic attention to the various types of learning, to the specific behaviors to be shaped, and to the strategies that can accomplish these objectives.

The point of view expressed here was described in preliminary fashion in an earlier article entitled "Why Is a Picture Worth a Thousand Words?" (11). It received concrete application in a film entitled Learning from Visuals: The Application of Programming Principles to Visual Presentations (10). The behavioral way of looking at "learning from visuals" is now given empirical support in this paper summarizing two research studies. The paper also offers further suggestions from a behavioral point of view as to some of the roles visuals can play in instruction.

The two studies undertaken in this project have adopted and extended the technology that has developed in programed instruction (one behavioral model) to pictorial presentations. They have accordingly been concerned primarily with: (a) techniques for bringing specific responses under the control of specific visual stimuli and (b) the use of visual stimuli possessing such control within the framework of an instructional strategy designed specifically for one kind of learning task--the acquisition of concepts and principles.

Study No. 1: An Investigation of Response Control during Visual Presentations

Study No. 2: Integrating Visual and Verbal Presentations

Both studies, described in detail elsewhere (8), were in the main concerned with how visual demonstrations might best be used to teach science concepts and principles. One study sought to teach Archimedes' Law; the other, concepts having to do with "force" and "pressure." Both studies involved the preparation of programed visual demonstrations and programed verbal materials. One study relied on a complete, solely visual lesson to teach concepts and principles. This was then integrated with a solely verbal lesson also designed to teach the same concepts and principles. The solely visual lesson was shown in its entirety either before or after the verbal lesson. In the second study, visual and verbal lessons were divided into small segments, with each segment devoted to a few concepts. Their integration was accomplished through the serial intermixing of visual and verbal segments. It is this latter study that provides a paradigm for the optimal integration of the single concept film (presented in pictorial terms) and other forms of instruction (programs, lectures, seminars, etc.). It also offers a paradigm for the integration of visual and verbal materials in a single integrated film or television lesson.

Verbal programs used in the two studies were typical linear programs requiring constructed responses; the responses required became increasingly longer and more complex. The visual programs presented on TV constituted a departure from conventional uses of visuals in instruction and represent a different form of programing. Each program or program segment was designed to teach the discriminations and generalizations that underlie the concepts and principles to be taught. For example, following the presentation of a demonstration of the difference between an object's weight in air and in water (a discrimination or distinction to be acquired), the student was expected to predict the apparent change in weight that would occur for another different-sized object. By being exposed to a variety of such practice opportunities, the student acquired the generalization for all objects (that there is a change in scale readings when objects are first weighed in air and then in water). Students selected their answers from multiple-choice pictorial options. Based on such practice, all concepts were acquired in both studies on the basis of programed visual demonstrations. The accompanying verbal material served to provide the more technical language a scientist might use in explaining the same phenomena.

This was the general approach used in both studies. Each study was devoted to other separate issues. These will be discussed, as they apply, in the sections that follow.

Achieving Stimulus Control

In keeping with the prescription of a programing model, visual presentations were designed to bring specific student responses under the control of specific visual stimuli. Upon presentation of such problems as the weighing of objects in air and then in water (the stimulus), the student was expected to predict the outcome--what the change in scale reading would be (the response); or when provided with an outcome as stimulus (the tearing of paper in a lesson on pressure), he was expected to indicate which way a wooden oblong would have to be deployed on the taut sheet of paper (the response). When such appropriate responses can indeed be made to the stimulus materials, stimulus control is said to have been achieved.

If all we mean by "stimulus control" is that students make appropriate responses to specific stimuli, then evidence that stimulus control has been achieved must come from student responses themselves. The most direct evidence that responses were in fact systematically brought under the control of specific elements in either the visual presentation, the verbal presentation, or both comes from an inspection of responses made during the presentations, that is, responses made on cue to the stimulus materials themselves. Based on workbook protocols obtained during program tryouts and during the experimental sessions in Study No. 1, it is apparent that the frequency of correct response to the visual presentation was quite high (approximately 85 percent). This suggests that responses made during the "active response" presentation were in fact effectively brought under the control of the visual stimuli. By "active response" is meant anticipatory responses to partly prompted lesson materials (e.g., predicting what would happen in a demonstration). A direct comparison of "correct response" frequencies for this, the experimental group, and for a control group is not possible since the control group was not required to respond actively or overtly (i.e., they made no predictions; they merely watched). Thus, the most direct evidence for comparing how well alternative treatments achieved stimulus control is not available.

Looking at the less direct, less immediate evidence of achievement test results, it is possible to compare the two treatment groups observed. The two treatment groups, it will be remembered, differed only on the basis of whether or not they responded actively. On verbal test items, the group that responded actively clearly surpassed the group that merely watched the visual and verbal presentations. On a test administered after the visual presentation only, there was a statistically significant difference in gain scores. As noted in the left-hand part of Table 1, the active response group outperformed the "passive" watchers. Further, as noted in the right-hand part of Table 1, on tests administered at various intervals after both the visual and verbal presentations were completed, the differences in gain scores observed between the two groups became progressively larger. While the gain scores for the active response groups declined moderately from the immediate test to the two-week delayed test to the four-month delayed test, the gain scores for the passive watchers declined sharply. The longer the delay in measuring retention, the more clearly was the active response group favored.

The results in Table 1 showing the beneficial effect of active responding both on acquisition and on retention are not particularly novel. They are consistent with majority findings from a large body of research on "participation techniques" (1). What is novel, however, is the extension of these findings to presentations that include programed, solely visual lessons designed to teach verbal concepts. These lessons were programed in such a fashion as to bring student responses systematically under the control of the nonverbal visual stimulus materials. The evidence reported here indicates that for this purpose active responding is superior to passive viewing.

TABLE 1

COMPARISON OF GAINS IN VERBAL TEST SCORES FOR ACTIVE RESPONSE AND NONACTIVE RESPONSE GROUPS (Total Score Possible = 17 Points)

	Test After Visual Presentation Only		Immediate Posttest		Two-Week Delayed Test		Four-Month Delayed Test	
Groups	Mean Gain	S.D.	Mean Gain	S.D.	Mean Gain	S.D.	Mean Gain	S.D.
Active response	3.56	(2.81)	4.78	(3.00)	4.33	(3.07)	4.00	(2.45)
Nonactive response	1.22	(3.30)	3.17	(2.36)	1.66	(2.57)	.58	(2.18)
Analysis of difference in gains between groups	F = 4.71* df = 1/30		F = 3.11 df = 1/30		F = 7.61** df = 1/30		F = 11.32** df = 1/20	

*Significance at the 5 percent level.
**Significance at the 1 percent level.

Data Suggesting Possible Roles for Visuals in Instruction

While achievement test results bear only indirectly on whether or not stimulus control is attained, they do bear directly on whether effective instructional strategies have been devised. On the strength of the results obtained in Study No. 1, that is, (a) that nonsignificant differences in total test scores between visual and verbal treatments were obtained and (b) that relatively high achievement levels were obtained for both treatments, it is apparent that programed discrimination practice involving solely visual events can effectively teach verbal concepts and principles. In reaching this objective, no differences between visual and verbal presentations were observed on total test scores (see Table 4). However, differences in the relative effectiveness of the visual and verbal presentations were revealed by separate analyses based on scores on either visual or verbal test items. These differences will be described in the sections to follow.

Interactions between Stimulus Mode, Response Mode, and IQ

As measured by verbal test items only and noted in Table 2, there was a significant interaction in Study No. 1 between IQ and mode of stimulus presentation. While above-average students appear to have profited more from the verbal presentation than from the visual presentation, below-average students tended to profit more from the visual presentation. (In subsequent t-tests, only the former finding proved statistically significant.)

TABLE 2

COMPARISON OF GAINS IN VERBAL TEST SCORES FOR HIGH AND LOW IQ STUDENTS RECEIVING EITHER A VISUAL OR A VERBAL PROGRAM (Total Score Possible = 22 Points)

	Mode of Stimulus Presentation			
	Pictorial		Verbal	
IQ	Mean	S.D.	Mean	S.D.
High	2.5	(2.5)	4.8	(3.4)
Low	4.4	(3.1)	3.6	(3.7)
Analysis of interaction	F = 4.56* df = 1/76			

*Significance at the 5 percent level.

Although the results favoring a visual presentation for below-average students failed to reach statistical significance, they are consistent with findings of other studies and are therefore suggestive (6,15, 27). Moreover, in Study No. 2, a statistically significant interaction was observed between IQ and mode of response (see Table 3). One group of students made active verbal responses (multiple-choice options) to a visual presentation. A second group made active visual responses (multiple-choice pictorial options) to a comparable visual presentation. While above-average students profited more from responses to verbal options than to pictorial options, the reverse was true for below-average students.

TABLE 3

COMPARISON OF DELAYED TEST SCORES FOR HIGH AND LOW IQ STUDENTS IN THE PICTORIAL AND VERBAL RESPONSE GROUPS

	Mode of Response			
	Pictorial		Verbal	
IQ	Mean	S.D.	Mean	S.D.
High	27.4	(5.96)	31.9	(6.61)
Low	25.4	(9.68)	17.7	(5.06)
Analysis of interaction	F = 6.02* df = 1/32			

*Significance at the 5 percent level.

These findings from Study No. 2 showing an interaction between IQ and mode of response parallel the findings of Study No. 1 showing an interaction between IQ and mode of stimulus presentation. Together they suggest that learning of abstract concepts in science (even when it is measured by verbal test items) becomes easier for below-average students when it is based on concrete visual stimulus materials and on concrete visual responses to visual presentations. On the basis of the individual differences observed, programed visual lessons in science appear to be less difficult than programed verbal lessons. In support of this view, additional data will now be reported that, unlike the data just reported, cut across ability levels.

Transfer from Learning Situation to Testing Situation

It might generally be expected that transfer would be facilitated from the learning situation to the testing situation the greater their similarity (12). Not surprising, therefore, is the finding in Study No. 1, summarized in the left-hand part of Table 4, that the solely visual experience (compared to the verbal experience) led to superior performance on visual test items. Nor was it surprising that the verbal lesson, consisting both of verbally described concrete examples and abstract statements, proved a more effective prior experience for the relatively more abstract verbal items than it did for concrete pictorial items. While the verbal lesson did lead to successful performance on the verbal test items, it did not prove to be superior to the visual lesson in this regard (see the right-hand part of Table 4). Experience with concrete

TABLE 4

COMPARISON OF GAINS ON VISUAL AND VERBAL TESTS FOR STUDENTS RECEIVING EITHER A VISUAL OR A VERBAL PROGRAM

	Mode of Testing			
	Visual Test†		Total Test‡	
Mode of Presentation	Mean Gain	S.D.	Mean Gain	S.D.
Visual only	2.35	(2.98)	5.8	(4.4)
Verbal only	.95	(2.81)	5.1	(5.0)
Analysis of difference in gains between groups	F = 4.55* df = 1/76		F = .41 df = 1/76	

†Total score possible = 16 points.

‡Total score possible = 38 points including verbal test items.

*Significance at the 5 percent level.

visual examples in the visual lesson allowed for successful transfer either to concrete visual test items or to abstract verbal test items.

Concept acquisition based on the experience provided in the programed, solely visual lesson appears to have facilitated transfer to either a visual or a verbal criterion test. In contrast, concept acquisition based on a programed verbal lesson appears to have facilitated transfer less readily to the visual criterion test than to the verbal test. It appears, on the basis of this difference in findings for visual and verbal lessons, that for transfer to occur, similarity between learning situation and testing situation may be less important when learning is based on visual (pictorial) materials.

Transfer from One Learning Situation to Another

The effectiveness of the visual presentation can be measured not only by the transfer effects it had on a subsequent testing situation but also by the transfer effects it had on a subsequent verbal learning experience. An effective integration of self-contained programed visual lessons and self-contained programed verbal lessons appears to have been achieved when the visual presentation preceded the verbal. As shown in the achievement results of Table 5 from Study No. 1 and completion time data in Table 6 from Study No. 2, the visual/verbal order of presentation excelled the verbal/visual order.

TABLE 5

COMPARISON OF GAINS IN VERBAL TEST SCORES FOR STUDENTS RECEIVING DIFFERENT ORDERS OF PRESENTATION (Total Score Possible = 22 Points)

Order of Presentation	Immediate Posttest Mean Gain	S.D.	Two-Week Delayed Test Mean Gain	S.D.	Four-Month Delayed Test Mean Gain	S.D.
Visual/verbal	5.48	(3.23)	4.71	(3.42)	5.36	(2.50)
Verbal/visual	3.05	(4.19)	3.09	(4.17)	2.50	(3.92)
Analysis of difference in gains between groups	F = 5.19* df = 1/20		F = 1.97 df = 1/20		F = 5.69* df = 1/24	

*Significance at the 5 percent level.

In Study No. 2, with "time to complete" the self-paced verbal lesson as the dependent measure, it was shown that students took less time to complete a verbal program when it followed rather than preceded a visual lesson. The data from both studies, thus, suggest the facilitating effect a programed visual presentation has on a subsequent verbal learning experience. (Data available in the original report suggest that this finding was not due to the added learning opportunity provided by prior exposure to the visual lesson.)

TABLE 6

COMPARISON OF "WORK RATE" MEANS FOR VISUAL/VERBAL AND VERBAL/VISUAL GROUPS ON THE VERBAL PROGRAMS[†]

Order of Presentation	Mean "Work Rate" (in minutes)	S.D.	N
Visual/verbal	43.0	(4.88)	18
Verbal/visual	46.7	(5.26)	18
Analysis of difference between groups	F = 5.12* df = 1/32		

[†] Pictorial response group only.

*Significance at the 5 percent level.

These findings are interpreted to mean that concepts are more readily acquired when responding to concrete visual stimulus events is made to precede responding to more abstract verbal events. Concepts were, it is true, acquired on the basis of the visual experience alone, and apparently without difficulty. The more abstract and technical explanations embodying the concepts were, however, more readily and completely acquired from a verbal presentation when it followed rather than preceded the visual presentation.

Discussion

What can be made of the three groups of findings just discussed? One group of findings suggests that below-average students learn concepts more easily by means of discrimination practice based on visual stimulus events and visual (pictorial) response options. A second group of findings suggests that when concepts are learned through discrimination practice with visual stimulus events, the similarity between learning situation and testing situation may not be, as if often the case, as important for transfer to occur. A third group of findings suggests that positive transfer effects from one learning situation to another are more likely to be obtained when learning based on a visual experience precedes learning from a verbal experience than when the reverse order is followed. Based on all three groups of findings presented here, how are the advantages that visuals seem to provide to be interpreted?

The results which require interpretation are these: Why is visual experience easier than verbal experience (as evidenced by the fact that below-average students tend to profit more from it than from the verbal experience), and why does visual experience tend to facilitate transfer across modes more readily than does verbal experience?

Difficulty Level of Visual Experience

a. Due to everyday experience with shapes, colors, sizes, etc., responses to attributes of physical objects and events are generally at high strength. On the other hand, responses to verbal symbols for the same phenomena, or for abstract referents, are not likely to be at equally high strength. Because of these differences in response strength, the relative cue-value of visual and verbal examples is likely to differ. As a result, the appropriate discriminations and generalizations on which the acquisition of concepts depends are apt to be more difficult when they are based on verbal rather than on visual examples.

b. The objects or events in visual examples rarely consist of single attributes to which students must respond. More often than not they consist of such phenomena as changes in attributes (as, for example, a change in color or size); causal relations (as, for example, an apparent loss of weight when an object is submerged); comparisons of attributes (as, for example, the relative magnitude of the forces being applied to the two ends of a lever); long sequences of events (as, for example, the assembly of coils in an electric motor); etc. Visual stimuli in science demonstrations are thus not single, simple stimuli but often consist of dense patterns, complex combinations, or chains of stimuli. The more complex the patterns, the combinations, or the chains, the more difficult are responses to them apt to be. In connected-discourse subject matter--science, for example--verbal stimuli are also rarely single words; most often they consist of chains of words forming sentences of varying degrees of complexity. Difficulty of response to sentences is thus likely to be greater than the difficulty of response to single words. The question arises: Is the visual "sentence," then any less difficult than the verbal sentence? It is assumed here that because of the lesser difficulty level of the separate components of the visual concrete "sentence," the complex of visual stimuli is likely to be still less difficult than the complex of verbal stimuli.

c. The value of a stimulus for cuing a correct response is apt to be a function of how univocally stimulus and response are related. Verbal stimuli (words) are apt to have more associations than are visual stimuli, and response competition, as a result, is therefore more apt to occur. The cue-value of verbal stimuli is thus likely to be less dependable.

d. There is evidence from research on the concept learning process which suggests an explanation for the relative ease of the visual lessons. Bruner (3) found that when students are required on their own to arrive at a concept, it is easier for them to categorize attributes of phenomena than to verbalize the principle. Unlike traditional studies of concept learning in which concepts are arrived at inductively by the student without guidance (save for that provided by the definition of the task), induction of concepts in this study was guided. The task required of the student in the visual lesson was essentially a guided, categorizing task. Students were required to categorize pictorial options (portraying outcomes) as being the same as or different from outcomes they had already seen demonstrated. The task of the student in the verbal lesson, however, was by definition more highly verbal. Thus, the issue resolves itself into one of the relative difficulty of the two tasks: guided categorizing of physical attributes vs. guided verbalizing of principles concerning physical phenomena. Concept formation studies, like the Bruner study, suggest the lesser difficulty of the former task.

Transfer from Visual to Verbal Experience

a. The observed superiority of the visual/verbal order of presentation, as measured by achievement results in Study No. 1 and latency data in Study No. 2, suggests a facilitating role for visual materials when they precede verbal materials covering the same concepts. There is evidence from research on paired-associate learning that an optimum condition is obtained when visuals are in the stimulus position and words in the response position (18,20). Conflicting findings are also reported from other studies using different tasks (2). There is also evidence from research on procedural learning that prior visual familiarization with parts of equipment facilitates subsequent learning to select and use the parts (14,28).

The learning that occurred in this study, unlike that in the two sets of studies just mentioned, involved the acquisition of concepts, first on the basis of a solely visual lesson and then again on the basis of a purely verbal lesson. The technical language and the long verbal chains describing concepts appear to be better acquired when they follow rather than when they precede a visual demonstration. This appears to be not unlike the frequent experience in everyday life where words are learned for the concrete objects and events around us. Our experience of visualizing words is a much less frequent occurrence. One possible explanation of the superiority of the visual/verbal order of presentation in the classroom is that it capitalizes on a well-established learning set.

b. The latency data of Study No. 2 indicated that work rates on the verbal program were reduced when the verbal followed the visual program. This suggests that generalization occurred from visual to verbal experience. To account for this generalization across modes, it may be pointed out that verbal responses to physical dimensions of the visual events are most likely already in the student's repertoire. Indeed, they are likely to be at high strength. Thus, it is highly probable that during the visual presentation, verbal responses are thus likely to have mediated the generalizations that occurred from visual lessons to the subsequent verbal lesson (or to subsequent verbal testing). With visual responses to verbal events likely to be at relatively low strength, it is thus not surprising that they are not likely to be available to mediate generalization from verbal learning to visual testing.

Conclusion

Complex and highly abstract concepts and principles can be acquired on the basis of programed, solely visual demonstrations. To rely on solely visual lessons for these purposes, however, results in marked inefficiency. Study No. 1 attempted to test the limits of what could be done with a solely visual lesson. While it has been amply demonstrated that concepts in science can be learned from such lessons, it is also evident that considerable savings in time could have been effected by even a moderate use of words during the presentation. Subsequent experience with programed demonstrations has shown that even if language is introduced, the advantages of a lesson using concrete visual materials are not lost if the language used describes concretely, rather than explains, what is occurring (as in Study No. 2). A single word, as has been aptly put, can be worth a thousand pictures.

Words serve an important cuing role when incorporated into a visual presentation. When they follow it, they serve other functions. The data obtained in this study suggest that students can answer verbal items based on programed, solely visual lessons. What a subsequent verbal experience appears to accomplish over and above this experience is the facilitation of longer verbal chains and the use of more sophisticated technical language to describe and explain the same phenomena. As educators, we may be content if students demonstrate mastery of concepts without the use of such technical language. Ultimately, however, it is probably more expedient and practical for them to master this language so that continuities and discontinuities among principles may be better understood and so that students can come to communicate with others. For these reasons, visual and verbal experiences are perhaps best integrated or combined. On the basis of the results of the present study, a visual/verbal order appears to constitute an effective combination for this purpose.

The visual/verbal order of presentation is optimally effective when the visual portion is designed, on its own, to teach the concepts to be acquired. Through discrimination practice based on pictorial events and on pictorial response options, concepts are acquired and the subsequent verbal experience rendered less difficult.

The use in these two studies of the visual stimulus mode, the visual response mode, and the visual/verbal order of presentation offers a paradigm for integrated, full-length televised or film presentations and for single concept films integrated with other media of instruction.

Instructional Strategies Involving Visuals

Visual demonstrations were used in the two studies described in this report to meet one particular type of instructional objective, namely, to teach student understanding of science concepts and principles. Students were, for example, expected to be able to define the term "pressure" or to compute the amount of pressure exerted or to state what the relationship between "force" and "pressure" was. The visual presentations were designed to implement an instructional strategy suitable for this objective. Had the instructional objective been different--say, to teach students how to make observations during the conduct of an experiment or to recognize examples in nature illustrating the principle being taught or how to perform the same experiments being demonstrated--other demonstrations would have been prepared and other responses to them practiced as called for by the strategy suitable for these differing objectives.

What role can visuals play in a strategy employed specifically for teaching concepts and principles? To see how visuals might fit in an instructional strategy suitable for this purpose, some general comments on strategy formulation may be helpful.

General Comments about Instructional Strategies

When instructional objectives are adequately stated, they include a specification of: (a) end-of-course stimulus contexts under whose control responses are to be brought, *e.g.*, a student being able to provide a definition in response to the verbal question, "What do we mean by pressure?" and (b) the response (or classes of responses) to be made, *e.g.*, "pressure = force divided by area." Suitable instructional strategies must specify the kind of learning experience that will lead to the fulfillment of such objectives.

The generalaim of an instructional strategy is to create the kind of learning experience that will ultimately lead to the criterion performance either on a test or beyond the classroom as called for by instructional objectives. Strategy formulation might be based on the assumption that the transfer of learned responses from the learning situation to the criterion situation would be expected to be optimally facilitated the more closely the two situations are alike. That this is not an invariant condition, however, is amply attested to by data from the present study, *i.e.*, pictorial responses to pictorial stimuli facilitated student performance on a criterion test that contained verbal test items calling for verbal responses. Criterion performance in the learning situation and criterion performance beyond the classroom may thus vary from virtual identity to nonidentity. The nature of some possible variations will be explored below.

What prescription for lesson construction must a strategy provide? To meet instructional objectives, strategies involving either words or pictures must specify: (a) the stimulus contexts in the "learning situation" under whose control responses are to be brought; (b) the responses to be brought under control; and (c) the conditions and techniques for bringing about such control. Decisions about each of these three sets of specifications are based on the assumption that successful performance in the particular kind of learning situation devised will facilitate successful criterion performance beyond the classroom. This assumption holds whether stimulus contexts used in the learning setting and the responses practiced are identical with those in the criterion situation or whether they differ markedly from each other.

a. Stimulus contexts. The anticipated outcome of a learning experience is that responses come under the control of a simple stimulus or classes of stimuli (in whatever mode). In the case of concept learning, this means that students learn to make the same response to equivalent classes of stimuli. The driver learns to stop at all red lights or at signs that read "stop" or upon a policeman's signal. Or the student can respond on a test indicating that he has learned that objects weigh less in water than in air, no matter what their shape or size. He can do this whether the test item is presented pictorially or verbally. These are criterion performance outcomes (on a test or outside the classroom) resulting from a learning experience in the classroom.

Criterion performance, in the case of concept learning, consists of one of a class of functionally equivalent responses in the presence of one or a class of functionally equivalent stimuli. To be capable of such a criterion performance, the student must practice the same or functionally equivalent responses in the presence of a functionally equivalent context provided in the classroom. The learning context may be identical with the criterion context; for example, responding to a program item requiring a written definition of the word "pressure." It might be substitute context, possibly bearing some measure of similarity to the criterion context (*e.g.*, everyday language used instead of technical language). Or it might be qualitatively different from the criterion context. It might, for example, be visual demonstrations of "pressure" phenomena (*e.g.*, the same total force, as represented by a given number of blocks, distributed over different areas) even though the criterion performance is a verbal test (as was the case in this study).

Stimulus contexts in the learning situation and in the criterion situation can differ in terms of: (1) the modality in which they are presented; for example, pictures used in the learning situation when words or symbols constitute the criterion situation (*e.g.*, the number line used to teach addition and subtraction of positive and negative numbers) or the converse; (2) the fidelity with which one reproduces the other (within the same modality); for example, a real object represented by a model in the learning situation; or (3) the comprehensiveness with which the learning situation samples the elements of a criterion context.

Because it is desirable that transfer from learning situation to criterion situation be optimally facilitated, emphasis might therefore be duly placed on achieving maximal similarity between the two situations. Accordingly, a strategy might call for use of a learning context similar to that in the criterion situation. As exemplified by the case of visual contexts used in the present studies, other considerations might enter. Some of these other reasons for selecting a visual learning context, even though the criterion context is verbal, will be detailed in a succeeding section.

b. Responses. The distinction between "criterion" and "learning" situations applied to stimulus contexts under whose control responses are to be brought applies as well to responses. Responses made in the learning situation may vary from identity to nonidentity with the responses to be made in the criterion situation. Differences between the two situations may be a function of either: (1) the topography or locus of a response (for example, practicing a verbal response when the criterion performance requires a nonverbal motor response); (2) the mode of response (for example, practice in recognizing a correct response when construction of a response is the goal); or (3) the response task posed the learner (for example, in the learning situation the learner's task might be to construct a sentence, whereas in the criterion situation his task might be to complete a sentence; or in the learning situation his task might be to evaluate the correctness of someone else's performance as a means of preparing him subsequently to engage in it himself).

Responses selected for practice in the learning situation (however different they may be from the criterion response) must be capable of resulting in criterion performance. In the present study, multiple-choice responding to pictorial options resulted in a criterion performance consisting of responses to test items representing a range of response types including pictorial, verbal, multiple-choice, and constructed responses. Thus, it is apparent that the response practice devised in this study facilitated transfer across modes such that students were prepared for the specified criterion performance. A rationale for a strategy calling for the use of pictorial responses during learning, even though criterion responses were verbal, will be offered in a succeeding section.

c. Conditions and techniques for gaining response control. The ultimate objective of a strategy is to bring criterion responses under the control of criterion contexts. The strategy first specifies the learning contexts and the learning responses, which are judged capable of producing the end-of-course criterion performance. Not only are stimulus contexts specified, but stimuli that are used merely to produce responses are also specified. For example, a visual stimulus may be employed not because we wish responses to be brought under its control (thus serving as a context); rather, it may already possess such control, and we may wish control to be transferred from it to the other stimuli. In this capacity it serves only as a cue. Thus, in its role as a cue a visual may be used to facilitate transfer of control to some other stimulus. Strategy considerations in selecting visuals for this role would involve their capacity, relative to that of verbal cues, for example, for cuing particular responses. It is apparent, therefore, that strategies must specify not only criterion learning contexts and responses but also all other learning responses and stimulus cues on which criterion learning performance is contingent.

Other strategy specifications would include a description of the conditions under which learning responses are brought under the control of learning contexts so that criterion performance is indeed assured. Specifications of conditions of response practice that can bring this about include a determination of prompting strength at various stages of learning; amount of distribution of practice; how the acquisition of necessary discriminations and generalizations can be facilitated; etc.

It is apparent that criterion performance in the learning situation and criterion performance at the end of the course (whether on a test or on the job) may differ either with respect to stimulus contexts or with respect to responses. However different they may be, the strategy calling for a particular learning experience is designed in such a way as to bring about criterion performance whether on a test or beyond the classroom or training setting.

As revealed by the data of the current study, what are some of the roles visuals can play in such strategies?

Role if Visuals in Instructional Strategies

Three principal roles may be described for visuals. In an earlier report (11), a distinction was made between criterion and intermediary visuals. Criterion visuals are those that appear in the criterion situation and are the stimulus contexts to which the student is expected to respond. To bring appropriate responses under their control, they may appear in the learning situation and, in addition to being criterion contexts, they also serve as learning contexts. For example, in order to be able to identify laboratory apparatus, the actual equipment might be used in the learning situation and students given practice in identifying it. Because visuals are integral to the criterion situation, they are used in the learning situation so that the responses acquired there will transfer to the criterion situation. This is one role visuals can play.

In the earlier discussion of visuals, intermediary visuals were described as those that already possess stimulus control over responses to be practiced. They are not integral to the criterion situation and hence do not constitute criterion stimulus contexts. Although not part of the criterion situation, they are used in the learning situation so that control may transfer from them to the stimulus contexts that are part of the criterion situation. For example, pictures to which students can respond with an appropriate identifying label (the pictures thus possess stimulus control) may be used to teach reading. The student comes to make the appropriate response (cued by the picture) to the printed word. Stimulus control is thus transferred from the picture to the word. This is the second role pictures may play. In this role as a cue, which merely produces a response so that another stimulus may gain control of it, visuals play an intermediary, instrumental, or practical role.

In the second role just described, control of a specific response is passed from one stimulus to another, with the two sets of stimuli being topographically different (for example, control over oral reading responses passing from a picture to a printed word). In a third role, also an intermediary role, topography of stimulus and response may differ. As in the study performed here, pictorial responses to pictorial stimuli facilitated subsequent verbal responding to verbal stimuli (test items). Concepts acquired on the basis of the visual presentation generalized across modes, so that students could respond to verbal contexts (verbal test items) even though no verbal responding was required. Despite the absence of such a requirement, it may be inferred that correct verbal mediating responses were occurring. It is precisely because verbal responses are in fact under the control of the visual stimuli and their strength quite high that visual stimuli are used. Because of such high response strength, it is assumed, verbal mediating responses are likely to be made to the visual presentation. It is this form of mediation, it is hypothesized, that can account for the generalization that occurred across modes (from pictorial responses to pictorial stimuli in the learning situation to verbal responses to verbal stimuli in the testing situation). Had some feature or dimension of a visual presentation not had stimulus control over a mediating verbal response, then it is unlikely that generalization would have occurred from visual learning to a criterion performance requiring verbal responding (17).

What are the considerations involved in the use of such intermediary visuals (and responses to them) which may differ in modality from criterion contexts and criterion responses? Why use them instead of using actual criterion contexts and criterion responses in the learning situation?

The question may be illustrated with a practical example. For teaching the discriminations and generalizations that underlie concepts and principles in science, it is possible, as shown by data from two studies, to choose between visual and verbal examples. Examples in either mode provide appropriate contexts to which students must respond. Having seen a number of prior demonstrations illustrating the apparent loss of weight that occurs when objects are weighed in air and then in water, a student is then presented with a new visual context. He is shown still another object weighed in air and instructed to predict whether the reading on the scale will increase, decrease, or remain the same. The same context might be presented in words, and following a series of prior verbally stated examples, the student would be instructed to predict what would happen to still another verbally described example. Based on such response practice with either visual or verbal contexts, students in this study came to acquire the concepts and principles in Archimedes' Law. What are the rational considerations on which a choice might be made between presentations of visual rather than verbal examples? What strategy considerations are involved?

Manipulating response difficulty.--There is evidence from both studies described in this report to suggest that science concepts are more easily acquired from visual rather than verbal examples. This was particularly true when the visual mode was used for both stimulus materials and response options. The ease that the visual mode affords in both cases, it was suggested, derives from well-established associations. High strength responses are already under the control of visual stimuli and can readily facilitate concept acquisition. Whatever the interpretation, the data revealing both individual differences in learning from visual and verbal materials and the transfer-facilitating effects of visual presentations suggest that concept acquisition can be made easier through the use of visual (pictorial) presentations. To what practical uses might such a finding be put? Three possibilities suggest themselves: (a) accommodation of individual differences; (b) reduction of the difficulty level of complex subject matter, and (c) setting difficulty levels appropriate to stages of learning.

a. Accommodating individual differences. Recently completed research by Gagne and Gropper (5) failed to reveal any significant relationship between special aptitudes, particularly visual aptitudes, and a person's capacity to profit from visual presentations. The results of the present study do not suggest the possession of any special aptitude as calling for visual presentations. On the contrary, it would seem that it is the absence of aptitude, particularly verbal aptitude, which is the largest component in such IQ measures as Otis IQ, that does appear to call for the use of visual presentations. The evidence suggests that below-average students were better able to acquire the concepts taught in both studies by means of pictorial presentations and pictorial responses than by means of counterpart verbal material. Far from possessing any special visual aptitudes, below-average students can respond to visual examples because, it is suggested, along with their brighter counterparts, they have had considerable prior experience in responding to the concrete attributes of many physical objects and events. Such examples are therefore capable, with high probability, of eliciting appropriate responses. Doing well with visuals--far from being a special aptitude--constitutes, so to speak, an easy task.

The two studies reported here were based on the performance of eighth graders. It is reasonable to suppose that the advantages that visuals have for below-average eighth graders might also accrue to students throughout the ability distribution at still lower grade levels. Based on the assumption that at lower age levels the capacity for abstract (verbal) thought is even more diminished, visual presentations using concrete stimuli might be more readily recommended for them.

b. Reducing the difficulty level of complex material. An instructional strategy might specify a wholly visual (or at least partly visual) presentation for below-average students or for very young students as a way of facilitating learning. For complex materials, learning might be facilitated for all, regardless of ability or of age, through the use of a similar strategy. The use of the number line to teach the addition and subtraction of positive and negative numbers comes to mind as an example of such an approach. To the extent that visual techniques can be imagined, formulated, and implemented for such purposes, they might be recommended as a means of reducing the difficulty level of what would otherwise be complex and not easily acquired concepts or principles.

c. Setting difficulty levels to match stages of learning. It is fairly axiomatic in programed instruction that learning progresses from what is known to what is unknown, from what is easy to what is difficult. Various strategies are possible for this purpose. The difficulty level of vocabulary can be manipulated. Familiar verbal examples can be used to explicate what is new and abstract. To facilitate ease of response, the mode chosen for response practice can be varied. In the REP style of programing, for example, Gropper (9) requires production responses only after editing responses and these, in turn, only after recognition responses. As in the case of these various strategies, the use of visuals in early stages of learning can similarly serve to make responses less difficult.

In the present study, the findings of two experiments have shown the advantages of visual presentations that precede rather than follow a more abstract verbal presentation. Being easier, the visual presentation appropriately comes first to match the stage of response readiness of the learner.

* * *

For any of the three purposes just described, one of the conditions of the learning experience that can be manipulated through the use of visuals is response difficulty. One of the consequences of such manipulation is the possibility of controlling the frequency of student errors. Error control is a concern because of its assumed relation to achievement. Recent results reported by Kress and Gropper (19) support such an assumption. Based on two programs and two groups, four correlations were obtained between the number of errors committed and achievement scores. On one program, the correlations for the two groups were -.64 and -.65 and on the second program, -.67 and -.70. Despite the fact that the variability of the error distributions was sharply curtailed, sizable negative correlations were obtained indicating that the more errors students made on programs, the lower were their achievement scores. If, then, there is justifiable concern about error control, the relative ease of visual materials suggests the visual modes as another possible instrument for achieving it.

By proposing pictorial contexts and pictorial responses, the educator can formulate a strategy that can render the learning experience easier. Pictures can be used to cater, as it were, to the response readiness of the learner as this is influenced by the complexity of the material, by the student's particular abilities and experience or lack of them, or by the stage of learning he is about to enter.

The pictorial mode is selected for the learning situation not because criterion contexts are similarly pictorial but because the conditions of learning can be altered. Intermediary visuals, rather than criterion visuals, are used because they make learning easier (11). Pictures are thus used for practical reasons.

Facilitating transfer.--To make transfer more likely, it is sometimes appropriate to build criterion contexts into the learning experience. Thus, when visuals are both intermediary and criterion at the same time, transfer might be expected to be optimally facilitated. When the criterion situation contains visual contexts, it is reasonable to expect positive transfer to occur when students practice responses to identical or similar contexts in the learning situation. What of those criterion situations, however, that do not contain visual contexts? Suppose a criterion test, for example, consists solely of verbal test items. What occurs when the learning situation consists of pictorial responses to pictorial contexts? On the basis of the data reported in Study No. 1, it appears that departure from similarity between learning situation and criterion situation is not nearly so crucial when programed visuals are used to teach concepts in science.

The findings of the present study seem to indicate that when the learning experience is verbal, students do well on only the verbal test. When the learning experience is visual, students do well on both visual and verbal tests. Transfer across modes appears to occur more readily from visual to verbal than in the reverse direction. In addition, data concerning transfer that occurs from one learning situation to another learning situation also suggest the superiority of the visual/verbal direction.

It may well be that in addition to altering response difficulty, a visual/verbal order of presentation capitalizes on the well-established set of associating words with visual experience. Thus, it is highly likely that visual presentations produce mediating verbal responses. On the other hand, the opportunity or need to visualize our words does not seem to be as insistent in our everyday experience. Consequently, the verbal/visual order of learning or transfer from verbal learning to visual testing is not likely to benefit from mediating visual responses. The greater likelihood of verbal mediation (rather than visual mediation) may in part account for the superiority of the visual/verbal order of presentation and, when learning is based on visual experience, for the lesser need for similarity between learning and criterion situations.

The visual/verbal order of presentation appears to be superior to the reverse order for two reasons:

1. Pictorial responding to pictorial material is likely to be easier (for concept learning) than is verbal responding to verbal material. Since early stages of learning are deliberately made easy, visual experience should precede verbal experience.

2. Since the integration of words and pictures requires transfer from one to the other, the visual/verbal order of presentation is preferred. This is the order in which transfer appears to occur best.

Other Strategy Considerations Suggesting Further Research

Visuals may play still other roles in instructional strategies. Suggestions about such roles will merely be offered here either because the data relating to them from this study are fragmentary or because the present study did not investigate them at all. They are to be considered as issues meriting further study.

a. Providing a variety of learning contexts. Concepts and principles are more easily acquired, and perhaps better applied, when a broad range of examples is employed to teach them. One way to vary the breadth of learning contexts is to present examples in more than one stimulus mode. Data from Study No. 1 demonstrated that a visual presentation and a verbal presentation (in that order) excelled not only the reverse order of presentation but also two presentations of either the verbal lesson or the visual lesson. Thus, a mixed visual and verbal treatment proved superior to a wholly visual and to a wholly verbal one. However, since these latter two treatment conditions merely involved the repetition of the same examples in the second presentation of the lesson, the conclusion to be drawn about breadth of contexts is not so clear-cut. The comparison that needs to be made is, therefore, between a visual/verbal presentation and a solely verbal or solely visual presentation that have comparable variety of examples. Should the visual/verbal presentation still prove superior, then this effect would not entirely be attributed to the manipulation of response difficulty (as discussed above). Variations in mode of stimulus presentation might then be considered to be a facilitating factor in the acquisition of a generalized response, i.e., a concept or principle. Generalization across visual and verbal examples is not likely to occur, however, unless the relevant visual stimulus dimensions have verbal responses under their control and unless these responses are at high strength. These are hypotheses for future testing.

b. Facilitating learning tasks. It was just suggested that a mixture of visual and verbal examples might facilitate the generalization of responses to new situations. It is also suggested that it might be worth exploring the possibility that visual examples alone rather than intermingled with verbal examples might facilitate the acquisition of the discriminations and generalizations on which concepts depend. One possibility is that it might require fewer visual examples for a generalization to be built than would be the case if verbal examples were used. Should these visual examples require less time to present, there would be a decided advantage in using them. However, watching science demonstrations sometimes requires more time than reading a verbal printed statement of an example. Advantages would have to be sought elsewhere--for example, in better retention of the concepts they illustrate.

As to discriminations, might there be advantages to using visual stimulus materials rather than verbal materials? Might they, too, not be acquired on the basis of fewer examples if the examples are visual? Might not the possibility of simultaneous contrasting of examples (particularly with static visuals) rather than contrasting successive examples (usually the case with verbal examples) prove more effective and efficient?

The use of fewer examples on which the acquisition of generalizations and discriminations depend suggests rather paradoxically that even though it may be easier to respond to visual examples than to verbal examples, step size may be increased. If students are brought to criterion level performance on the basis of fewer examples, each step along the way would obviously be larger.

c. Facilitating transfer. The results presented here (successful performance on verbal test items even when learning was based on pictorial experience) indicated that transfer across modes occurred. It was hypothesized that this transfer was mediated by verbal responses. It was further hypothesized that had not such verbal responses been under the control of the pictorial stimuli, transfer would not have occurred. Research in which strength of verbal responses to pictorial stimuli is manipulated can be designed to disclose whether concept acquisition (measured verbally) based on programed pictorial presentation depends on such verbal mediation.

The inferior transfer from verbal learning to visual testing was further interpreted in terms of the lack of high strength visual responses available to mediate such transfer. Comparable research could be designed in which pictorial response strength is also systematically manipulated. Further meriting study are the techniques whereby pictorial responses to verbal stimuli might be brought to higher response strength. At such high strength, they might be capable of playing the mediating role they are often assumed to play.

It can be readily seen that the issues outlined above--those for which this study has provided answers and those requiring further research--stem from behavioral considerations, from an analytic view of the learning processes and the variables of which they are a function. Many other issues could be suggested, but the ones described here are restricted to those stemming from the research just completed.

Summary

The integration of words and pictures in the two studies reported in this paper was accomplished quite unconventionally. In one study, an entire topic, Archimedes' Law, was covered in a self-contained, entirely pictorial lesson and also in a self-contained, entirely verbal lesson. Students acquired all the concepts and principles making up Archimedes" Law first on the basis of one lesson and then again on the basis of the second. In a second study involving a lesson on "pressure," only one or two concepts or principles were covered in each visual segment and then again in each verbal segment. It required all five visual segments in the lesson to teach all the concepts and principles. Similarly, it took all five verbal segments to teach all the concepts and principles. Thus, the only difference between the two studies was that the lesson in the second study was segmented. What was common to both studies was the provision for the acquisition of the discriminations and generalizations underlying the concepts and principles to be taught solely on the basis of programed visual material, solely on the basis of the programed verbal material and then on the basis of both sets of materials combined.

In the visual/verbal order of presentation, a student acquired the discriminations and generalizations (necessary to understand the concepts being taught) on the basis of the pictorial materials first; he then acquired them once more, in more technical language, on the basis of verbal materials. For example, on the basis of the solely visual lesson on Archimedes' Law, he learned the principle that objects weigh less in water than in air. The subsequent verbal lesson taught him that there "is an apparent loss of weight" when objects are weighed in water.

This procedure whereby programed visual lessons on their own are used to teach concepts is quite different from the conventional use of pictorial material. Typically, a visual example is used to precede or to follow a verbal statement or principle or a verbally described example. Rarely is a sufficient number of visual examples used, and rarely is the opportunity afforded to practice the necessary discriminations about the examples so that the relevant concept is fully acquired on the basis of the visual examples alone. In conventional uses of pictures, concepts cannot be acquired either on the basis of the visual example(s) alone or on the basis of the verbal example(s) alone. In contrast, in the procedure used in these studies, concepts were fully acquired on the basis of either the visual or the verbal series of examples. Thus, when the recommendation is made that visuals should precede the verbal treatment, it does not mean that a single visual followed by verbal statements or principles will suffice. The concepts must be first acquired on the basis of the visual treatment (using as many examples as needed), and only then should the same concepts be covered in the verbal treatment. The purpose of including the verbal lesson is to teach the student the technical language describing the concepts he already understands.

An efficient integration of words and pictures would appear to call for the following prescription: the use of a single concept film (using visuals) followed by verbal materials (whether in print, in lecture, or in film or televised form). Pictures and words would be serially intermixed as called for by a particular instructional strategy. Visual presentations would be designed to facilitate acquisition of the discriminations and generalizations on which understanding of concepts and principles depended. Further, pictorial responses to such presentations would be required. One role that visuals of the sort just described can play in an instructional strategy is to make concept learning easier. This strategy would be followed for students of lower verbal ability or for young students, for all students when concepts to be learned are complex, and for matching difficulty requirements at various stages of learning. Also, since it appears desirable that visual and verbal experience be integrated, a second role visuals can play (when they come first) is to facilitate transfer to a subsequent verbal learning experience.

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Aside from the substantive findings they provided, the two studies reported here represent a systematic attempt to apply learning theory considerations to the use of visuals. They were based on an analytic look at the various roles visuals can play in instruction (e.g., cuing responses; reinforcing responses; serving as examples to facilitate acquisition of discriminations and generalizations). Further, the studies were based on the assumption that these various roles will prove variably beneficial, depending on the particular type of learning task to be facilitated. In this study students had to learn concepts and principles. Had their learning task been different--say, to learn a language, to learn how to solve problems, or to acquire motor skills--then different strategy considerations and different roles for visuals would have been devised. The optimal use of visuals thus would appear to depend on an analytic look, generally, at the roles visuals can play in instruction and, more specifically, in facilitating particular kinds of learning tasks.

These considerations stem from a behavioral way of looking at learning from pictures. Further research can provide evidence as to the adequacy of learning theory to account for such learning. Only as such evidence accumulates and learning theory becomes increasingly comprehensive can applied problems be readily solved. The quickest route to their solution, it is suggested, is through the rigorous testing of a theory rather than the eclectic, ad hoc borrowing from learning theory and from communication theory to account for particular phenomena.

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PSYCHOLOGICAL BASES FOR INSTRUCTIONAL DESIGN

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If it can be agreed that the science of psychology must supply the knowledge for the precepts of instruction, then it follows that the translation of scientific knowledge into practice requires technological development. However, at this point in time, an entity known as an educational technologist or an instructional designer hardly exists in our society. If such a person did exist, a framework could be suggested in which he might carry out his job. This paper describes and discusses such a framework.

First, this psychologist-instructional designer would analyze the subject-matter domain he is considering--reading, mathematics, and so forth. He would think of a domain in terms of the performance competencies which comprise it. He would analyze representative instances of subject-matter competence in terms of the stimulus characteristics of the content to be attended to, and the properties of the responses the student makes to the content (by responses is meant broad activity ranging from memorizing to concept learning to problem solving); he would further analyze the structural characteristics of the domain, perhaps in terms of its conceptual hierarchies and operating rules. Second, the instructional designer would turn his attention to the characteristics of the students that are to be taught. He would need to determine the extent to which the students have already acquired some of the things to be learned, the extent to which they have certain content prerequisities, the extent to which their antecedent learnings might facilitate or interfere with the new learning, and the extent to which the students have certain aptitude-like prerequisities consisting of necessary sensory discriminations and motor skills.

These first two steps conceivably provide some information to the educational designer about the target performance to be obtained and the existing preinstructional behavior of the learner. The designer must now proceed to get from one state to the other. This sets up third task, which consists of guiding or allowing the student to go

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from the preinstructional behavioral state to a state of subject-matter competence. This requires the construction of teaching procedures and materials that are to be employed in the educational process. As part of this process, the educational designer must take account of motivational effects and the ability of humans to generalize and extrapolate by providing conditions which will result in the maintenance and extension of the competence being taught. Finally, the educational designer must make provision for assessing and evaluating the nature of the competence and kind of knowledge achieved by the learner in relation to some performance criteria that have been established.

To many present-day educational practitioners, this description of the process of instructional design may sound harshly technological, and, indeed, perhaps some elegance has been lost in analysis. But, presumably, once basic techniques are constructed, the teacher can use the tools of his profession with understanding, artistry, and sensitivity.

The design components that have just been described are (a) analyzing the characteristics of subject-matter competence, (b) diagnosing preinstructional behavior, (c) carrying out the instructional process, and (d) measuring learning outcomes. Further comment can be made about each of these.

Analyzing Subject-Matter Competence

When the psychologist turns his attention from analysis of standardized arbitrary tasks used in the laboratory to the analysis of the behavior generally taught in school, he runs head-on into the problem of what is coming to be called task analysis. This is a relatively new phenomenon for the psychologist because in the laboratory he has decided upon and constructed an experimental task pertinent to his particular purposes. He is not in a position to do this in the educational situation. In the laboratory, by preselecting his task to fit a problem, he has in a sense analyzed its stimulus and response characteristics. With real-life subject matter, he is faced with the problem of identifying the properties of subject-matter stimuli and their associated responses. Procedures for task analysis are still quite primitive, but recent exemplary models are to be seen in the work of Gagné (5,6) in mathematics and the work of E. J. Gibson (8) in the stimulus aspects of reading. The analysis of subject-matter tasks which identifies the stimulus and response requirements of a subject-matter domain affects instructional design and frequently will suggest innovations in instructional procedures.

A subject-matter scholar usually can divide his subject into subtopics primarily on the basis of content interrelationships and subject-matter logic and arrangement. In contrast, a psychologist considers subject-matter analysis more in terms of the behavior of the learner and the kind of stimulus-response situations involved. Content and subtopic repertoires are terms that can be used to refer to a subject-matter oriented analysis. The term "component behavioral repertoire," or merely "component repertoire," can be introduced to refer to a behavioral analysis.

From the point of view of instruction, component repertoire analysis identifies the kind of behavior involved so that the learner can be provided with instructional conditions optimal for that kind of behavior. The underlying assumption here is that the learning of various kinds of component repertoires requires different kinds of teaching procedures. The important research task is to identify the learning processes and appropriate instructional procedures associated with different component repertoires. For example, this kind of thinking underlies Gagné's recent book on the Conditions of Learning (7). He lists categories of behavior such as chaining, verbal association, multiple discrimination learning, concept learning, principle learning, and problem solving, and he suggests learning conditions relevant to each category.

A broad distinction with respect to component repertoires has been made by Skinner when he distinguishes between formal and thematic repertoires (18). In a formal repertoire, there is point-to-point correspondence between stimulus and response, as there is in such activities as imitating, copying, and beginning reading. In thematic, or mediated, repertoires, responses are controlled by interacting sets of variables without formal correspondences between stimulus and response, as is the case when one asks a question and one gives a meaningful nonimitiative answer. In language learning, there are certain formal repertoires such as taking dictation, transcribing, and reading. There are also thematic repertoires which involve syntactic sequences, grammatical structures, and contextual constraints of the language. Much of the work to date in operant conditioning is relevant to the learning of formal repertoires. Recent research on mediation obviously relates to the learning of thematic repertoires.

The properties of a subject matter which have been identified by some sort of an analysis of tasks determine the dimensions along which the student is taught to generalize and transfer his knowledge. Presumably, the ability to generalize and transfer is a function of experience with a variety of examples and different subject-matter instances. For some dimensions of subject matter, there is little ambiguity about generalization gradients and about what constitutes a variation of instances about a basic rule. However, as a subject matter becomes more complex, definition of a range of examples becomes more difficult, and problems arise concerning whether training in various instances does indeed carry over to new situations. What is required is analysis of stimulus variation and generalization gradients in the dimensions and multidimensions determined by the properties of the subject matter.

The influence of the analysis of subject-matter dimensions can be seen clearly when one considers the teaching of very simple concepts. In learning color concepts, such as red and blue, a child must learn to make the same responses to all members falling within a stimulus class and to make different responses to members of different classes. That is, the child discriminates between colors but learns to generalize to objects which differ in properties other than color--red squares, red circles, etc. Once the appropriate dimensions of the task have been analyzed, these are handled systematically in the teaching procedure, and dimensions not relevant to the concept being taught are varied randomly so that the student learns to generalize among objects having in common no characteristic other than their color. So the child learns the concepts of redness and blueness. This is the simple case, however; the instructional process becomes complicated when the subject-matter properties to be generalized and discriminated are not so clear-cut or are very subtle. For example, consider the concepts of early or late Mozart. A major problem with teaching such subtle and complex concepts is analysis and definition of subject-matter properties. This becomes increasingly problematical when there is disagreement among experts and where there are semantic imprecisions. Sometimes the distinction between classes is not clear to the learner because he does not have the preliminary training required. At other times the confusion is subject-matter imprecision itself (15).

These comments so far, referring to the analysis of subject-matter domain, suggest some of the concerns involved. At times one is almost convinced that until more is learned about the familiar variables we study in the laboratory, the major influential component for improving instruction is the rational and empirical analysis of subject-matter tasks. At any rate, it is the first step in the sequence of steps required for instructional design, and without it, the succeeding components will be inadequate.

Diagnosing Preinstructional Behavior

Once the subject matter and the content of the related behavioral objectives have been analyzed, the instructional designer turns his attention to the characteristics of the learner. This raises all of the problems involved in diagnosing preinstructional behavior or, to use other terms, in assessing his entering repertoire. Here, a major schism between the two main disciplines of scientific psychology gives us pause (2). For a measurement psychologist, diagnostic testing has been a primary concern; for psychologists interested in learning, attention to preinstructional individual differences has, for the most part, been relegated to error variance. It is increasingly obvious, however, that a psychology of learning relevant to educational practice cannot consider individual differences as error variance. Classroom and laboratory studies are constant reminders that individual differences, one of the most important conditions of learning, are seldom recognized, for all practical purposes, in either learning theory or subject-matter teaching (19). In work with programed instruction, one is uniformly impressed with the extent of variability in student learning rates (11, 22). It is well to be aware, however, that rate of learning is only one relevant dimension of individual differences and--at least in the context of programed instruction--is the easiest dimension to accommodate. Other equally or more important variables pertain to the component and content repertoires of the student, that is, his aptitude patterns, skill level, etc.

At least four classes of preinstructional variables are determinants of the nature of instruction--excluding personality-type variables (23, pp. 423-427): (a) The extent to which the student has already learned the behavior to be acquired in instruction. If one gives the final test in a course as a pretest, it is not uncommon to find that a portion of the students display the behavior they are to be taught. (b) The extent to which the student has acquired the prerequisites for learning the knowledge to be acquired; for example, knowing how to add before learning to multiply. Again, a pretest often shows the absence of the behavior necessary for a student to begin new instruction. (c) Another preinstructional variable is learning sets which consist of antecedent learnings that facilitate or interfere with new learning under certain instructional conditions. (d) Finally, there are aptitude-like variables which consist of the ability to make the discriminations necessary to profit from instruction; for example, aptitude in spatial visualization. These kinds of entering competencies which vary among individuals obviously influence what is learned and what can be taught.

In the instructional process, just as the analysis of subject-matter competence determines the target behavior to be attained, so does preinstructional behavior define the beginning point for guiding behavior through teaching. Certainly this is true if one does not or cannot control or delimit student behavior up to the point of entry into instruction.

The array of variables and concepts involved in the preinstructional measurement of aptitudes, readinesses, and diagnostic measures of achievement must be systematized for increased understanding of how they interact with learning and for use in instructional design. It is conceivable that long-term prediction by aptitude tests of achievement scores at the end of learning might be supplemented by measures of behavior which predict whether the individual can achieve the next immediate instructional step, and Cronbach (1) has pointed out that in certain of the new curricula, some data suggest that aptitude scores correlate less with end-of-course achievement than they do with achievement in early units.

If we consider the assessment of preinstructional behavior as the determination of an entering behavioral repertoire which the instructional process is designed to guide and modify, then research becomes reoriented in a number of areas. In the analysis of readiness, for example, measurement of the fact that readiness factors differ with age and with individuals must be supplemented by analysis of the conditions influencing these differences and the contribution of these differences to learning. The approach to developmental norms requires reconsideration: When is a child "normally" capable of distinguishing a b from a d so that it is useful to teach him to learn to read? Prevailing norms necessarily presume prevailing learning conditions and not new learning environments. Research on aptitudes might be reoriented. If designing instructional environments for early ages is considered, it is conceivable that the "curriculum" will not be formal subject matters like mathematics or reading, but instruction in behaviors which look more like aptitudes. In tackling the problems involved in considering preinstructional repertoires, the important jobs are first to investigate the relationships between individual difference variables and learning variables (How shall individual differences be conceptualized in learning theories?) and second, and more practically, to construct teaching systems for the accommodation of education to individual differences.

Carrying Out the Instructional Process

In the framework being presented, once the content and component repertoires involved in terminal objectives and intermediate subobjectives have been described, and once the preinstructional state of the student is described, the instructional process can be carried out. If entering behavior is considered state A and a subsequent performance objective is state B, then the instructional process is designed to arrange the student's environment to get him, or, if one prefers, have him get himself, from state A to state B.

For ease of thinking about the instructional process designed to produce subject-matter learning, at least three kinds of processes that seem to be involved can be postulated: (1) setting up new forms of response, such as new speaking patterns or a new skill like handwriting; (2) setting up new kinds of subject-matter stimulus control, such as attaching already learned speech sounds to particular visual symbols; and (3) maintaining the behavior of the student. This third category is less involved with behavior change and more concerned with increasing the student's likelihood to behave, and in this sense falls under the general label of motivation. These three categories can be briefly elaborated:

A very evident characteristic which leads to subject-matter mastery is the increasing precision of a student's responses. In learning complex behavior, the student's initial performance is variable and crude and rarely meets the criteria of subject-matter competence. Effective instructional procedure tolerates these initially crude responses and gradually takes the student toward mastery. In accomplishing this, the instructional process involves the establishment of successively more rigorous standards for the learner's performance. This increasing competence is established by gradually contracting the permissible margin of error, or, put another way, by contracting performance tolerances. An example of this is teaching precise timing and tempo to the music student. The student's beginning performance will be quite variable, and performance criteria should be initially gross and changed at a rate which assures continuing progress toward mastery.

Over the sequence of instruction, the range of student performance will align itself with the particular range of acceptable performance defined as subject-matter competence which the student reaches or exceeds. Inappropriate construction of performance criteria can be a hallmark of ineffective instruction leading to extinction and frustration. The process just described is often referred to as shaping by people who think in operant conditioning terms.

An equally, if not more significant process than shaping in subject-matter learning is the process of setting up the stimulus control of performance. For example, in second language learning, it is easy to think about the transfer from an initial repertoire to a target repertoire. In teaching translation, one stimulus class is transferred to another while the response is kept the same. The response "flower" is transferred from the English word _flower_ to the German word _die blume_. In learning a concept, the responses "apple," "peach," and "pear" are transferred from the specific objects, as stimuli, to the word _fruit_. The pertinent instructional process involved here is restructuring the student's entering repertoire so that certain responses are transferred to the control of new stimuli. The notion here is that the transfer of stimulus control is a major process involved in teaching students to make responses to more precise subject-matter discriminations and also in teaching them to use previously learned skills in response to new stimuli.

The two processes just described assume only that the behavior of an expert in a given subject matter is characterized by the facility by which it is called out by particular subject-matter contexts. However, a further characteristic of an expert's behavior is that it is apparently self-sustaining. The expert may continue to work for relatively long periods of time without seeming external support and without the various supports that are needed by the novice. Not only then is the expert's behavior controlled by the subject matter, but with increasing competence, it can be characterized as self-sustaining. Research on the learning and teaching of self-sustaining behavior is an interesting problem related, perhaps, to exploration and curiosity.

Conditions Influencing Instruction

Within the kind of categories just described, the task of the experimentalist thinking about instructional design is to examine the conditions which influence these processes. Some of these aspects which are especially interesting for research and development in instruction can be mentioned. They are sequencing, stimulus and response factors, practice, and response contingencies.

Sequencing

The sequencing of behavior in instruction is a condition of learning which requires detailed analysis. The notion of gradual progression, highlighted in programed instruction, is related here; however, more subtle analyses are required. Subject-matter scholars frequently point out that their subject is not organized as sequentially as, say, mathematics is, and hence their instruction cannot be so carefully sequenced. In addition, they say that their subject matter requires that many considerations be handled at one time and that these must be taught as a whole so that the student can perform in an integrated fashion. However, when one undertakes to lay out details in instructional sequences and establish partial attainment goals, the "all-things-at-once" idea seems to fall (14). Decisions need to be made, on some basis, concerning what is to be learned before what. This sequencing requirement cuts across many areas of interest in psychological research. Transfer of training is involved; an increasing number of studies indicate that generalization and transfer to new situations cannot reasonably be assumed, and the identification of the structure of subconcepts determining the nature of transfer is a central problem in learning theory.

The apparently simple matter of a progression of difficulty in learning hierarchies can be quite complex. The variables influencing learning difficulty can involve an astonishing number of factors. In an analysis of variables influencing sequencing in learning to read, Silberman (17) lists word frequency, letter frequency, syntactic structure, meaningfulness, redundant patterns, pronounceability, word and sentence length, word familiarity, stimulus similarity, and grapheme-phoneme correspondences.

Stimulus and Response Factors

In addition to sequencing conditions, it is necessary in instruction to decide upon the ways in which the student can perform, in order to determine how subject-matter material will be presented to him. This point has already been mentioned in considering the analysis of subject-matter domain determine the dimensions along which a student can interact with his subject matter. In present-day instruction, since printed materials carry so much of the burden of instructional presentation, educators have scarcely begun to investigate new possibilities for providing interaction between the student and his subject matter. It seems possible to be able to present the learner with ways of seeing and manipulating his subject matter that extend and enrich his contact with it and form a learning environment in which subject-matter dimensions need not be so drastically reduced as they may be when forced into a primarily paper-and-print learning environment. Engineering and engineering psychology have worked on the experimental analysis of the display and response characteristics by which a human can communicate with his environment. Similar concerns must be expressed in education with respect to the interface between student and subject matter. We need to examine the display and response characteristics by which a student can interact with a subject-matter discipline. As an example, consider the importance of the development of graphical input and output facilities in automated instructional systems which can remove the student from the restrictions of keyboards and one-dimensional inputs. In computer-assisted instruction, a major innovation seems to be required in the form of input and output consoles which seem possible with existing technology (10).

Amount of Practice

The amount of practice variable should be mentioned only because it seems to be disappearing in emphasis, as such, in experimental psychology, but is very much a topic in educational methodology. In work with programed instruction, one becomes increasingly aware of how little is known that can be applied about the variable of practice, which is an old and respectable topic in learning. With the present techniques for designing programs, the amount of practice and review employed needs to be completely empirically determined and is highly influenced by individual differences. The situation is highlighted by such studies as one in which one-fifth of the frames of a published program were removed, and average performance for the original version and the shortened version showed no differences. Amount of practice as a condition of learning may be completely subsumed by or may highly interact with the influence of transfer hierarchies, mediating relationships, and such other aspects of subject-matter structure. The entire question of practice and review with meaningful subject matter needs to receive extensive experimental investigation.

Response Contingencies--Errors and Correction

It is well known that the consequences of an individual's actions serve to modify his behavior, and these response contingencies influence the course of learning. Because there are so many things which are not known, the study of the contingent relationships between behavior and consequent events is a key area for research in learning relevant to instruction. Many studies show the powerful influence of response contingencies, such as the reinforcement contingency; and then there are studies in which the authors conclude, "Fairly extensive feedback may be detrimental . . . and provide no support for the hypothesis that efficiency of learning varies directly with the probability of reinforcement" (21). Such negative findings need to be analyzed carefully, particularly with respect to an analysis of the component repertoire and the nature of the sequencing of instruction.

Response contingencies fall into several classes, reinforcing events being one class, and others being extinction, punishment, and another which can be called correction. Correction is highly relevant to instruction, but it has been generally ignored in psychological studies. It refers to the contingency whereby an incorrect response is followed by a stimulus event which informs the student of the nature of the correct response in such ways as telling him the right answer, showing him how to get the right answer, making him perform the correct response, and so forth. There has been work in corrective feedback in motor skill learning. A "correction trial" in animal learning means something different from what is meant here. There has been relatively little work in verbal learning. In some verbal learning studies, the investigators flatly assume that providing the correct answer following an incorrect response is a reinforcing event in the same way that confirmation following a correct response serves as a reinforcer.

The question involved is how do students learn from their errors. Some investigators (12) conclude that in multiple-choice learning situations, the presence of the incorrect alternatives increases the probability that the subject will repeat his error. In work done by Suppes and Ginsberg (20), they report the desirability of overt correction procedures following incorrect responses to facilitate learning in children. The suggestion is that there may be differences in the effects of correction between adults and children and also differences as a function of the behavior being learned. With respect to the kind of behavior being learned, an intuitive hypothesis is that formal repertoires may be learned more efficiently with highly determined correct-response reinforcement and that thematic, meaningful repertoires may profit from the use of corrective feedback.

In recent studies, there have been provocative contrasts on the subject of learning with errors versus learning without error (3). Skinner's teaching machine work has emphasized the minimization of error. In simple discrimination learning, there has been some questioning of theories in which the extinction of responding to an inappropriate stimulus and hence the occurrence of errors is a necessary condition for the formation of discriminations. The general rationale for error minimization in instruction seems to be the following: (a) When errors occur, there is lack of control over the learning process, and opportunity is provided for the intermittent reinforcement of incorrect responses. This results in interference effects highly resistant to extinction. (b) Frustration and emotional effects that are difficult to control are associated with extinction and interference from error. (c) Richer learning, that is, richer in associations, takes place when the associative history of the learner is applied to extend his learning. This is accomplished by mediators or thematic prompting which make positive use of existing knowledge and serve to guide learning. Perhaps another reason behind the drive to minimize error is, as has been said, that the use of errors and the possible value of incorrect responses have not been as widely nor systematically investigated as other response contingencies.

Individuals concerned with more adaptive teaching procedures than the Skinner-type linear program make the case that errors must be used in the course of instruction (13). Their procedures require that the student reveal, by making some sort of error, the kind of instruction he should receive next. If adaptive control is competently designed, student weaknesses are revealed by the student's selection of response alternatives. Where no adaptive procedures are available for dealing with error, the minimization of error is forced upon the teaching procedure. The advocates of error minimization recognize the presence of error but attempt to cue or prompt it out of existence in the course of designing a program for a particular population of students. Such non-adaptive programs attempt to remove error without allowing it to be manifested in overt mistakes. These programs of instruction which attempt to forestall error need to make provision for far more error possibilities than any one student is likely to have, and probably wind up with less than an optimal series of challenging tasks. The point of the above comment on error and correction is that an interesting area for learning research relevant to instructional practice is the study of the response contingencies which follow the occurrence of incorrect responses.

Response Contingencies-- Effective Reinforcers

Another general problem with respect to response contingencies is the question of what are the effective reinforcers in subject-matter learning sequences, and the related practical problem of what reinforcing contingencies can be employed in designing instruction. As is known, reinforcement can be quite subtle so that in teaching beginning reading, a textbook designed to be interesting may reinforce the behavior involved in obtaining meaning from printed material but may not differentially reinforce correct phonemic responses. Reinforcing events must be determined on the basis of detailed analyses of appropriate subject-matter and component repertoire relationships. It seems that just as one identifies what kind of objects feel hot or cold or pleasant or frightening, one needs to identify what events can serve as reinforcers for certain subject matters.

Learning studies suggest the effectiveness of certain events as general reinforcing conditions. Two interesting leads can be mentioned. Premack (16) has pointed out that of any two responses, the one that occurs more often, when both are available, can reinforce the one that occurs less often. For example, if, for a child, playing is a higher strength behavior than eating, then playing might be used as a reinforcing event for eating. Or, if certain words occur with a higher probability than others, they might be used as reinforcers for words that have a lower probability of occurring. This notion suggests that carrying out a learned performance can be reinforcing, and in a sequence of activities, each performance serves as a reinforcer for previous performances. However, a performance will act as a reinforcer only if it has a higher probability of occurrence than the behavior it is reinforcing. This has some direct suggestions for the design of instructional sequences.

Another apparently powerful reinforcer in learning is overt control of the environment. Reinforcement of this kind seems to be related to the study of curiosity and exploration (4). Research has identified that significant variables which influence exploratory behavior are characterized by stimulus objects or patterns that are novel, unfamiliar, complex, surprising, incongruous, asymmetrical, etc. All of these aspects can generally be described as a change in the environment which confronts the individual. It appears that the strength of exploratory behavior is positively related within limits to the degree of change introduced into the environment. The individual encounters such change by way of his ineraction or manipulation of his environment, and this environmental change, in turn, elicits curiosity and exploratory behavior. Investigations have further demonstrated that behavior that leads to a change in the environment is learned. Thus, in addition to environmental change eliciting exploratory behavior, experiments show that stimulus change can be employed selectively to reinforce behavior. Following from this, it can be hypothesized that environmental change resulting from highly manipulatable instructional situations can bring about desirable characteristics of curiosity and exploration in subject-matter learning. The suggestion is that a student's curiosity and explorations may be both elicited and selectively maintained in an instructional environment which provides for appropriate variation and change in both the stimulus characteristics of the subject matter confronting the student and the responses required of him by these materials.

Measuring Learning Outcomes

The fourth component of instructional design is the measurement of learning outcomes. It is clear that an effective technology of instruction relies heavily upon the detailed measurement of subject-matter competence at the beginning, in the course of, and at the end of the educational process. The increasing emphasis on instructional design in recent years has raised questions concerning the nature and properties of measures of student achievement and the assessment of subject-matter competence as it may be defined by subject-matter scholars. Some of these questions have been raised particularly with respect to (a) the distinguishing characteristics of achievement measurement versus aptitude measurement, (b) the differences between norm-referenced and criterion-referenced tests, and (c) the use of tests for differentiating between individual students in contrast to differences between instructional treatments (9). A most thought-provoking article along these lines is one written by Cronbach (1). He writes, for example, "I am becoming convinced that some techniques and habits of thought of the evaluation specialist are ill-suited to currect curriculum studies. . . . How must we depart from the familiar doctrines and rituals of the testing game?" (p. 672). Particularly with respect to instructional design, test data are important indicators of the properties of the learning environment that effect certain behavioral changes. Achievement test data are becoming increasingly significant as the design of instruction becomes a more rigorous enterprise. This final component of instructional design concerned with measuring learning outcomes concludes the points to be covered in this paper. It is hoped that the four components of instructional design that have been mentioned can provide some structure for thinking about the important problem of instructional design and its relation to psychological knowledge.

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TRANSMISSION OF INFORMATION

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During the last two years a number of students and faculty at the University of Utah have been studying some of the problems related to the transmission of information through the use of audiovisual displays. The project, sponsored by the Educational Media Branch of the U.S. Office of Education, has led to the . . . exploration of some of the conditions related to the effective transmission of information through the eye and the ear and to the examination of some of the propositions found in books on audiovisual materials which are presented as principles for the construction of teaching materials. Most books on the subject include two statements which provide a foundation to much of the material that generally follows. One of these is that more information is acquired when the same information is transmitted simultaneously through both the auditory and visual modalities than when a single modality is used. The other is that other things being equal, the more realistic a presentation, the more effective will be the transmission of information. Both of these propositions have a high degree of plausibility which has given them almost the status of cornerstones in the audiovisual field. They have generally been accepted without the careful examination which they deserve. The purpose of this paper is to subject them to critical examination.

Information Transmission through More than One Sense Modality

Interest in these propositions stemmed from the fact that while they fit some common prejudices, they do not fit the theoretical models developed by psychologists interested in perception and information transmission. Neither do they fit the theoretical conceptions which are emerging from physiology. First, on the psychological side there is the fascinating work of Broadbent (2), who has come to the conclusion that the perceptual system generally functions as a single channel system with information from only one source gaining access to it at any given time. The model applies only when the information handling capacity of the system is near to being fully utilized. It takes a surprisingly low input of information to meet this condition. The model also provides for

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a short-term storage in which inputs of information are held for a few seconds and then fade. The concept of a short-term storage is rather similar to Hull's concept of a stimulus trace. The importance of the short-term storage is that it permits the utilization of nonredundant information received simultaneously from different sources. The information received from one source or through one modality can be held briefly in the short-term storage, while the information arriving from the other source or through another modality is utilized. However, switching from source to source or from channel to channel takes time and is not easily undertaken with any rapidity. It is of interest to note that the model of Feigenbaum and Simon (5) derived from the study of rote learning is also that of a single channel system in which one item of information must be processed before another item can enter the processing system. A somewhat similar conclusion concerning the structure of the nervous system and its capacity for handling information is implied in the well-known work of the physiologist Hernandez-Peon and his associates at the University of Mexico. Colin Cherry (3), a communications engineer with a flair for experimenting on problems of transmitting information to human receivers, has also come to the conclusion that the utilization of information by the higher centers of the nervous system can be represented best by a single channel system. So far, there does not seem to be a single contemporary scientist who takes the position that the human can receive more information if exposed to two or more sources simultaneously than if exposed to one, nor if the information is transmitted through two sense modalities rather than one. The position of the research scientists and the designers of audiovisual materials are at such opposite poles that it hardly seems possible that both can be correct.

The evidence generally given to support the position of the audiovisual worker is a series of studies which began with a classic one conducted by Münsterberg nearly three quarters of a century ago. Unfortunately, these studies were conducted before the days when much attention came to be paid to tests of significance. Although they proclaim in unison that audiovisual transmissions of the same information provide superior learning to that produced by the transmission of the information through the auditory modality or the visual modality alone, the reader of the studies is left with the disconcerting impression that the differences might well have failed to reach the 5 percent level of significance, if an appropriate test had been applied.

An examination of this situation led to the undertaking of a set of very similar experiments which provided improved control over presentation conditions and which permitted the application of tests of significance. An associate at the University of Utah, Van Mondfrans (6) conducted a study in which nonsense syllables, words, and words with constraint were presented either through the auditory modality alone, the visual modality alone, or through both modalities. The task was a serial learning task administered at four different speeds. The syllables or words were presented one after another, and at the end of each presentation of the list, the subject was required to write down all those he could remember. The list was then repeated a fixed number of times, and the score of the subject was the number of errors to criterion. The results generally show no advantage for an audiovisual presentation over a presentation involving audio transmissions alone or video transmissions alone. At the faster speed a significant decrement was found in the audiovisual presentation, as if the use of two modalities resulted in interference of the one transmission with the other.

In the case of literary materials one would expect somewhat different results when the use of two sense modalities is compared with one. Many studies have shown that listening ability appears to be somewhat distinct from reading ability. If such is the case and if subjects are given the opportunity to both hear and see a passage, one would expect that each subject would tend to choose the modality of reception which was the most effective for him. Thus on an audiovisual presentation each subject would choose the modality most effective for him, and a group of subjects would thus receive the information better than when the material was presented through a single sense when some subjects would be penalized. This is what Robert Jester and the author have found when reading test passages were presented through hearing alone, through vision alone, and through both vision and hearing. At the slower speeds of 200 words per minute or less no advantage was achieved through the audiovisual presentation, but at higher speeds two things began to happen. First, many subjects took obvious steps to block one channel by closing the eyes or covering the ears and, second, despite this blocking of one channel, the audiovisual transmissions of information turned out to be superior to the single channel. Presumably, subjects tended to block the information channel which was of least value to them. Although superficially the evidence appears to negate the single channel model for information processing, our interpretation is consistent with the model. The data also point to some of the cautions which must be taken in interpreting evidence in the area.

Two sources of information coming through the same sense modality or through different modalities can be utilized simultaneously if the rate of transmission of information is very low. At higher speeds, where the information from a single source is more than the processing system can handle, switching from source to source may occupy a part of the time available for taking in information. Where, for example, there is an auditory and a visual input of information of relatively high information density (in relation to what the processing system can handle), then the switching process itself may interfere with the taking in of information. In a recent study by Reid, in the Utah laboratory, the data indicated a loss in learning related to the number of times that such switching occurred. The time lost in switching in this particular experiment comes near to other estimates and is about 200 milleseconds. This switching time appears to be time out from learning. An odd and interesting fact reported by Reid is that frequent switching produced considerable emotional behavior accompanied by expressions of hostility toward the experimenter.

An interesting phenomenon which has some bearing on the single channel concept of information processing which has been discussed has been found in the study by Chan, Van Mondfrans, and the author. The study stems from the controversy within the ranks of those who produce audiovisual materials concerning the value of using special effects such as music, color, elaborate settings, and so forth. Some producers believe that such elaborate settings hold the attention and increase learning. We studied this problem in a grossly simplified setting which may seem quite repulsive to the producer of educational movies. What we did was to have the same set of nonsense syllables prepared for slides in two forms. In the one form the syllables appeared in black type on a white background. In the other they appeared on brightly colored backgrounds, consisting of samples of wallpaper, and the syllables themselves were printed in exotic type of variable color designed by an artist. The visually presented syllables were accompanied simultaneously by a different set of auditorily presented syllables. Thus the task of the subject was to learn two sets of syllables presented simultaneously, one through the auditory channel and one through the visual, but different groups viewed different visual versions, one glamorized and one plain. The finding in this study was that the glamorized visual version produced greater learning with the syllables involved, but at the expense of the auditory channel. The total information received was the same with the glamorized and the nonglamorized syllables, but the distribution of the sources of the information was changed.

While up to this point consideration has been given to the case in which the primary purpose of using two sense modalities is either to transmit redundant information or to transmit nonredundant and unrelated information, the auditory and the visual transmissions of information can be related in a number of different ways. Sometimes auditory information is used to hook up visual information with previous knowledge. Very commonly the auditory information represents a name for a visual display. Another frequently found relationship is where an auditory cue indicates the part of the visual display which the viewer should single out for inspection. The systematic design of audiovisual teaching materials requires an inventory of such relationships and also empirical knowledge concerning the conditions which facilitate learning through these relationships. We have begun to explore such problems which will become the focus of our attention during the next two years. Preliminary results indicate that the relationship of the time of occurrence of events in two modalities are of crucial importance for effective learning.

The implications of the studies discussed in this paper may be summarized by saying that the data generally support a number of propositions which have implications for the design of audiovisual teaching materials. First, they support the proposition that no advantage is achieved by transmitting redundant information simultaneously through both the auditory and the visual modality, except where unusually high speeds of transmission are involved. These are speeds far in excess of those ordinarily encountered. Second, switching from the auditory channel to the visual, or the reverse, occupies time which appears to be time wasted insofar as learning is concerned. Third, devices which have been used to draw attention to the information transmitted through one sense modality tend to depress the information received through another. Fourth, in terms of broad implications, the data fit well a model of information processing similar to that of Broadbent or that of Feigenbaum and Simon. These models portray the information processing system as involving in its final level a single channel of limited capacity which can generally handle only information from one source at a time.

Realism and the Problem of Compression

Experiments on the transmission of information can provide dramatic evidence of the limited capacity of the human for utilizing information, though under ordinary circumstances the higher centers are sufficiently well protected that this limitation is not evident. A number of mechanisms exist which limit the inputs to the higher centers of the brain and prevent overloading. One of these already considered involves the blocking of all information except that from a single source. Another very important series of mechanisms are those involved in processes, referred to as compression processes, which appear to operate at almost all levels of the nervous system. These processes have been investigated by both physiologists and psychologists with results which fit rather well together. Communication engineers also have contributed to our knowledge of the compression of information by developing simulators of compression processes. The term compression does not have a single precise meaning in current literature. Generally it refers to one of two processes. First it may involve the removal of redundancy--a process which involves no loss of information. Second, it may involve the discarding of those aspects of a transmission which provide least information and the retention of those which provide the most. Let us consider the latter process first.

Some years ago Attneave (1) pointed out that in visual displays the boundaries of the objects presented provide more useful information than do other parts. This is why a line drawing or a cartoon has so much power as a transmitter of information--it provides information which is already, so to speak, precompressed. Attneave also developed a technique for compressing visual information which had the effect of reducing a photographic portrait to something resembling a pencil sketch. What remained after compression would be described as just the essential details. This process of compression resembles rather closely the corresponding physiological process of lateral inhibition which would have a very similar effect upon the transmission of visual information as it moves along the optic nerve.

Colin Cherry has gone a step further in attempting to compress visual information. Cherry, unlike Attneave, is not concerned with the problem of simulating physiological processes. His main concern is that of compressing visual information in order to provide economical electrical transmission. Nevertheless some of the demonstrations he has derived from various sources can teach psychologists some important lessons.

One demonstration shows, for example, that a visual display such as that of a face appearing on television can be compressed electronically to produce what appears as a simplified visual representation with edges and boundaries greatly accentuated and the areas between remaining blank. When this is done, the visual display is identifiable but lacks details. This, again, simply shows that edges and boundaries transmit more information than other parts of a display, but Cherry adds a still more important demonstration. Through the application of appropriate electronic processes, the compressed version of the picture can be reconstructed into a visual display which approximates the original so closely that the human observer has difficulty in distinguishing it from the original. The reconstructed picture, in fact, has only about half the information of the original, but the difference is hardly noticeable because the compression-reconstruction process is such that some of the visual noise is eliminated. The demonstration gives plausibility to the possibility that while only a small fraction of the visual information may reach the higher centers, an internal reconstruction may take place which provides the illusion that one perceives the world around one in the greatest of detail.

Information compression is a natural process which permits a limited capacity nervous system to handle a very complex environment. Without the compression of inputs of information, the nervous system would be overwhelmed. The effective transmission of information in educational situations involves the use of communications which are readily and effectively compressed by the receiver. How can one be sure that a particular communication can be readily compressed? One can never be very sure about this, so the safest procedure for effective communication appears to be to compress the material before it is transmitted. Most teachers generally do this without recognizing what it involves. Every classroom provides illustrations of precompressed information being transmitted to the learners. One of the most familiar of these is the line drawing on the blackboard which appears to derive its effectiveness from the fact that it presents those aspects of a visual display which carry the most information and suppresses other aspects.

The point being made here is that the emphasis on "realism" found in books on the design and use of audiovisual materials is the worship of a false god. The nervous system is not effective in dealing with the environment in all of its wealth of detail. It handles it by simplifying it, and it is through such simplified inputs and the resulting perceptions and conceptualizations that man learns to cope with a very complex universe. Through providing simplified presentations of the environment in learning situations, the teacher can be sure that the compression process is effective. When this is done, the separation of the important elements in the message from the less important elements and the noise in the message is not up to the learner who may fail to separate them. The separation is made for him. In this connection, it should be pointed out that some producers of instructional films, at the present time, are doing precisely the reverse. Such films are produced with visual displays highly embellished, not just with color, but with complex artistic adornments, and the sound channel is cluttered up with music and other sound effects. The evidence seems clear that such a procedure is not the way to transmit information effectively.

While a considerable amount is known about both the physiological and the psychological processes involved in the compression of visual information, the same cannot be said about the compression of auditory information. Some knowledge has been derived about the compression of speech, but there is still an absence of any theory concerning how the nervous system handles both the very high redundancy of speech and the tendency of some words to carry much more information than others. The process which effectively compresses speech for transmission to a human receiver has to be compatible with the compression process as it takes place in the human auditory channel.

Probably the high redundancy of language is partly a result of the fact that it evolved under conditions of auditory transmission where effective transmission requires redundancy. The auditory mechanism is a sufficiently poor analyzer that such redundancy is necessary. It comes as a surprise for most persons to know that words selected at random from a dictionary and presented one by one on tape are often difficult to recognize. A language which had evolved for visual transmission would have required much less redundancy. Oddly enough, the auditory language requiring redundancy has been taken over intact in printed form where its level of redundancy is far above that which is necessary.

Various forms of compressing speech have evolved for reasons of convenience much as forms of compressing visual displays have crept into teaching. The typical telegraphic form of communication sent by an economy-minded patron of Western Union uses a form of speech compression. Artificial languages such as FORTRAN provide highly compressed communications as do the languages used for retrieving information in some of the modern library storage and retrieval systems. The latter systems are not designed for improving communications to human beings, but are links between human problem solvers and auxiliary problem-solving equipment. The problem to be considered in this paper is the different one of the compression of speech for communicating to human receivers, not machine receivers. That speech is redundant far beyond what is necessary for adequate communication seems clear, but the problem of removing a part of the redundancy and the more trivial information so that information can be communicated in less time is one which is being explored--one for which no ready solution has been found.

One method of compressing speech is referred to as time compression. This method is based upon the fact that very small amounts of speech may be removed periodically without altering the amount of information transmitted. A simple way of doing this is to transfer speech to recording tape and then to snip out small segments and splice the remaining segments together. To do this manually is laborious, but two machines have been invented for this purpose, one by Fairbanks, Everitt, and Jaeger (4) and the other by the Eltro Company, known as the Time and Pitch

Regulator. In discarding material, time compression does not do this very efficiently. Some syllables could be cut far more readily than others, but the machine discards at random. The syllable "tik" can be cut little without loss of intelligibility, but the syllable "sim" could be cut to less than 30 percent of its original length. Selective cutting would do a much better job of retaining the information than does the random discarding of elements of the sound track, but intelligent methods of compression are much more difficult to undertake than are random methods.

Time compression eliminates some redundancy, but compression of information in the nervous system appears to involve the discarding of the less important information and the retaining of the more important. At least this is so if one is to judge by the way in which visual information is compressed. Thus, time compression probably does a poor job of simulating auditory compression processes within the body.

Robert Jester and the author have undertaken some work related to problems of the compression of auditory information in connection with a project on the transmission of audiovisual information. Of particular interest are the effects of the audiovisual transmission of verbal information in contrast with the transmission of the same material through the audio channel or the visual channel alone. College students reading material from the "Davis Reading Test, Form 1a," at speeds up to 200 words per minute, comprehended the audio versions, the video versions, and the audio-video versions at approximately the same levels, but at higher speeds two things begin to happen. Auditory comprehension falls off much more rapidly than the video, and the audiovisual presentation begins to show an increasing advantage over either one of the single channel presentations.

The fall off in the comprehension of auditory material in comparison with the comprehension of the visual material must be commented on. There are several factors involved. The first factor is undoubtedly the fact that the speeding up of auditory material by time compression results in loss of intelligibility, but there is no corresponding loss through speeding the presentation of the visual material. The second is that the eye can scan reading material in such a way that the words or groups of words transmitting the most useful information are more readily received (this is a form of compression process), and as far as is known, there is no comparable mechanism for scanning auditory material. A third factor is that most persons have had some experience in receiving information at high speeds through the visual sense, but few have had comparable experience with high-speed audio transmission. A fourth factor is that the information needed to identify a word transmitted aurally takes an appreciable time to transmit, but when the same word is transmitted visually the entire information needed to interpret the word arrives at the receptor level at the same instant.

If auditory information is compressed by the human according to principles similar to those involved in the compression of visual information, then one must suppose that the result is an emphasis on those portions of speech which carry the most information and a suppression of those that carry the least. This is different from the elimination of redundancy as is done by time compression and might involve a greater emphasis on verbs and nouns at the expense of articles and prepositions. This is what is done in the telegraphic form of communication. Other forms of compression may also be introduced. A highly compressed form of communication is shown by those deaf persons who utilize sign language. In the widely accepted form of this language, the entire verb to be is compressed into a single sign involving the touching of the lips with the fingers.

Procedures for the compression of verbal information which had an effectiveness similar to those used in compressing visual information would have many important applications in the field of education. If a compressed language is evolved for some types of communication and for storage of information, there is reason to be confident that it will not involve time compression, but that it will involve a system compatible with the compression system used by the nervous system which, in turn, will have to be compatible with the coding system involved in the storage of information.

Finally, the point must be made that however efficient we may become in providing compressed forms of information for transmission, the transmission system must provide an effective means of external storage. Man behaves in many ways as if his capacity for storing information was very limited. In order to overcome this limitation, he has devised auxiliary information storage systems external to himself. Let me illustrate this point. Most educational psychologists do not have at their finger tips all the details of all the statistical methods they are likely to use. The typical educational psychologist has near his desk an array of books on statistics, and he is familiar enough with the contents that he can locate rapidly any procedure that he needs. The books function as an auxiliary storage system which supplements that of the psychologist and in which he can locate information because he has it coded into broad categories. Now an information transmission system, beyond the elementary school level, should provide a system for the external storage of knowledge in a way which permits the learner to have rapid access to it. The transmission system which is least effective in providing an external storage system is the modern learning program presented either in text or in machine form. No one who ever learns from such a program can use it later as a reference source. Textbooks are much superior in this respect. Man's limited storage capacity implies that he should leave an educational institution armed not just with the knowledge and skills which he has acquired, but equipped also with an external store of knowledge from which he can skillfully retrieve information.

There are several implications of some of the research reported in this paper for educational practice. First, flooding of the learner with information and a stress on realism is likely to provide a poor learning situation. Some schools have tended to do this as if expressing the hope that the more the sources of information are available, the more the learner will absorb. Such an approach overlooks the fact that the learner has a limited capacity system for utilizing information, that the learner can generally utilize information from only one source at a time, and that the capacity of the learner for processing information is limited. With this concept of the learner, an important role of the teacher becomes that of finding simplified representations of the environment which are compatible both with the objectives of learning and with the information handling mechanism of the learner. Some teachers already do this well on an intuitive basis, but what is needed is a set of principles which will indicate how information can be most effectively compressed and simplified prior to transmission.

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ON CHANNEL SWITCHING

by Robert M. W. Travers

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A particularly interesting phenomenon which has been ignored by those who specialize in audiovisual education is the time lost in channel switching. Since every contemporary book on audiovisual education takes the position that learning will occur most effectively when both the auditory and the visual channels are being, so to speak, saturated with information, the channel-switching phenomenon has been completely ignored. It is a phenomenon which occurs because of the single-channel nature of perception. Time loss in switching can be observed when the information density is such that it has reached the limit of the capacity of the organism to handle. This, of course, is a typical rather than an exceptional state of affairs. It is worth reflecting at this point that the educational sound motion film can hardly be used economically unless it is transmitting information at a rate near the limit at which information can be received by the learner. It is under just such conditions that the loss of learning through channel switching becomes most evident. This problem has not even been considered by the designers of those sound motion pictures which are to be used as teaching devices. From what has been learned . . . there would appear to be much in favor of educational motion pictures designed after the pattern of the old silent pictures which alternated print with visual displays. One alternative is the use of visual displays with subtitles. But this would appear to place too much strain on the viewer who must frequently change from the pattern of eye movements required for reading to the pattern of eye movements required for inspecting a complex visual display.

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Excerpted from Studies Related to the Design of Audiovisual Teaching Materials. Final Report, U.S. Department of Health, Education, and Welfare, Office of Education, Contract No. 3-20-003. May 1966. P. 266.

VARIABLES IN INSTRUCTIONAL FILM PRODUCTION

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Influence of Variables in the Film

Audience Involvement Factors

Six factors were identified as contributing to the involvement of an audience in a film experience. The evidence on the existence and influence of these factors may be summarized as follows.

Identification. As yet there is only weak unsatisfactory experimental evidence to support the theory of identification as a factor of audience involvement in motion picture experience, which results in an increment in various types of learning from the film. Much more exploration and experimentation are required on the relationship between identification and learning of various types.

Familiarity. When an audience is familiar with the setting and the type of activity shown in a film, it tends to become involved in the film. This conclusion is supported by both the Holaday and Stoddard, and Sturmthal and Curtis studies. But this conclusion must be qualified because familiarity alone does not inevitably involve an audience in the film. The things which are familiar must also have a personal meaning for the audience. If this were not the case, familiarity in film content would restrict the opportunity for learning and the results would have more of a reinforcing than a reorganizing effect on the individual's experience. While familiarity of material may result in a pleasant and satisfying experience, it may also result in very little more than nostalgic reminiscence.

Excerpted from Instructional Film Research: 1918-1950. Technical Report No. SDC 269-7-19, Instructional Film Research Program, Pennsylvania State University. Port Washington, L.I., N.Y.: Special Devices Center, U.S. Office of Naval Research, 1950. Pp. 8.31-8.34.

Subjective Camera. When an instructional film gives its audience a learner's eye view, rather than a bystander's view, more learning is likely to take place. The studies which support this conclusion suggest some qualification of the widely-held belief that more perceptual-motor learning occurs when the film presentation shows an exact representation of the learner himself performing the task. Roshal, in his study of knot-tying, found that when the camera pictured the learner's hands in a way that obscured the audience's view of the actual knot-tying operation, audience learning was impaired. Hence it appears that crucial cues, that is, cues which give the learner the important steps that guide him through the operation, are of greater instructional value than exact representation. Further, the data from Jaspen's study indicate that technical terminology is not necessarily one of the crucial cues.

Anticipation. Anticipation of situations in a film seems to govern the intensity of audience response. For example, when the audience anticipated fearful consequences in a film, it had a more intense reaction when it actually witnessed the event in the film. However, when "adult discount" is combined with anticipation, the emotional response may be less intense.

Participation. It is clear that audience participation, properly used, is effective when it involves practice of the behavior which a film is intended to influence. It is probagly most effective when used in such a way, and at such time, that a sufficient amount of learning has accrued to make practice feasible, as was done in the filmstrip on the phonetic alphabet. Furthermore, when actually teaching a motor skill in a film, participation is most effective when the task is not too complex or the speed of development of the film is not too rapid to interfere with practice.

In the available studies of information learning from films, such as the Yale experiment and the Instructional Film Research Program studies of the films on snakes and wrenches, questions and statements inserted in a film had little more practice value than a second showing of a film. In all cases, it is apparent that such practice as is involved in audience participation under favorable conditions is most likely to be effective when the behavior practiced is relevant to the objective of instruction.

The research data on audience participation have implications for both the producers and users of instructional films. Judicious use of participation techniques effectively incorporated into films, and employed after some initial learning has taken place, may increase the effectiveness of a film which is likely to be exhibited only once to its audience.

1. Dramatic vs. Expository Presentation. There is evidence of emotional involvement resulting during showing of well-produced dramatic films; whether similar involvement can be obtained from the expository type of film, remains to be demonstrated, but is doubtful. Dramatic

structure is no guarantee of involvement. Many factors seem to interact in producing involvement.

Whether the involvement aroused through dramatic structure will facilitate learning appears to depend upon the desired learning outcomes and upon the nature of the involvement produced. Dramatic structure may be more effective for certain learning outcomes than expository presentation, although this remains to be demonstrated. For instance, dramatic structure may be more effective for changing attitudes. All the studies on attitudinal changes from films have used either dramatic or documentary form, so the question is not answered. Expository treatment may be equally or more effective for informational learning.

2. Cartoon Form vs. Live Photography. Since none of the studies on this topic made a direct comparison between a cartoon and live photographic presentation of the same material, it is difficult to generalize on the effectiveness of cartooning as a presentation variable.

Cartooning omits all except the essential detail and often exaggerates the crucial characteristics of appearance and behavior. The cartoon thus seems to be an adaptable medium for presenting crucial cues. If these cues are proved to be an effective learning aid, then cartooning and other simplified pictorial techniques now being developed for television may relieve film producers of the tedious and expensive process of striving for exact representation.

Picture and Sound

Visual and Auditory Channels. There is some evidence that even in films in which the narration appears to contain the greater part of the instructional material, the visual element is almost as effective in communicating the material as the narration, provided the audience has some prior acquaintance with the subject matter. The visual and audio elements have a much greater combined effect than either one alone. The relative contributions of the visual and auditory channels seem to depend on the particular film, its content, the techniques used, and probably on the characteristics of the learners who view it.

Pictorial and Verbal Presentation. The studies comparing the effectiveness of pictorial and verbal presentation do not give conclusive evidence in favor of either presentation. Rather, they suggest that the problem involves the amount of emphasis to be placed on one or the other presentation. But it is evident that since the motion picture is primarily a visual medium, it should be used to portray that material which can be conveyed to best advantage by visual means.

Emphatic Devices. The study on general emphasis indicates that the film should make an expressed distinction between items having similar implications, and that the differentiation should not be left to the judgment of the learner.

Attention-gaining devices apparently add little to an otherwise well-made instructional film. Devices which call attention to irrelevant materials may interfere with the learning of more important items. However, it seems probable that devices which direct attention to visual elements which may otherwise be overlooked, may serve a useful purpose in facilitating learning.

Similarly, color appears to have been a distracting influence under some of the conditions studied, possibly because it distracts the learner from more important learning cues. Probably the steps involved in using color most effectively are to determine what the crucial learning cues are, and then to emphasize these cues by the color medium.

Verbalization. Research on the comparative instructional value of silent and sound films shows no clear-cut advantage for either medium. From this we conclude that how the commentary is presented is less important than what is said in the commentary itself.

These various experiments indicate that: (1) commentary facilitates film learning; (2) an intermediate amount of talk in the film commentary or narration is more effective than too little or too much talk; (3) direct statements are generally preferable in instructional films to the third-person passive voice; and (4) commentary which alerts the audience and orients it to some forthcoming action is preferable in "how-to-do-it" films to commentary which lags behind the action.

Film Music. There is little experimental evidence to suggest that musical background has any marked effect on learning from instructional films.

Film Structure

Repetition. The evidence comparing the amount of learning resulting from repeating certain sequences within a film shows that some repetition definitely increases the teaching and training effectiveness of a film.

Rate of Development. The various studies of rate or speed of development in films indicate that when a film containing a large amount of information presents that information to the audience at a rapid rate, the audience learns relatively little from the film. A slower rate of development definitely increases the efficiency of learning from such a film.

Introductions and Summaries in Films. The studies cited present some evidence that introductory and summary material may increase the amount of learning from films. However, there were no large learning gains to support this conclusion, due partly to instructional shortcomings of the films studied.

Thus, it is evident from the research on the rhetoric of film instruction (how to "say it" effectively with films) that an audience responds to a film and learns from it more effectively when (a) the audience becomes involved in the subject presented on the screen; (b) the story of the film is told visually, and verbalization at an optimal level is integrated with the visual presentation; (c) crucial sequences are repeated in the film; (d) the rate of development is adjusted to the rate of learning of the audience; and (e) the audience is oriented to the story or task represented in the film. It is also clear that any or many of these factors, if improperly employed in a film, may interfere with learning rather than facilitate or contribute to it. Too much talking, irrelevant introductions, unwieldy audience participation, fast rate of development, high density of facts, a too-literal representation which obscures the audience's perception of the crucial cues--all appear to detract from the effectiveness of films in instruction.

There is no evidence that the motion picture as a medium of communication is exempt from the rhetoric of instruction. As was pointed out in previous chapters, learning involves "suffering and undergoing." In a sense, films do not make learning, itself, "easier." But, if they skillfully employ these elements of the rhetoric of instruction they can facilitate learning, and thus make the instruction more efficient. It is axiomatic that instruction facilitates learning and that instructional films should be produced which will further facilitate the process.

PREPRODUCTION TESTING

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Technological advances in motion picture production have increased the quality and versatility of the products, but in doing so, have increased their cost and complexity to a point where the film maker who does not enjoy a strong financial position cannot risk an unsuccessful production. If such a film maker could have advance knowledge of the probable effectiveness of his approach in terms of learning, attitude formation, and the like, he could proceed with the comfortable assurance that his efforts were likely to be successful; or he could evaluate proposed changes in his script, scene content, or continuity before expending large amounts of time and money. The purpose of preproduction testing is to provide such information.

The rationale of preproduction testing is based on two premises: that the production of a film is not an end in itself, but a means by which some desired effect, in the form of teaching, entertaining, or influencing people may be achieved; and that the primary criterion by which a film must be judged is the extent to which it achieves that effect. As the use of films for specialized purposes increases, communication becomes more complex, and familiarity with systematic procedures by which effects may be predicted becomes a necessary tool of film making.

The contributions of many persons to the production of a film are well recognized, but for convenience in the discussion that follows, this entire congeries of artists and technicians will be referred to under the name "film maker" or "producer," as though they were a single person.

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When the Use of Preproduction Testing Is Indicated

A test to determine the effectiveness of a film is most readily conducted and is maximally profitable when one or more of the following conditions are present:

1. The producer's intent is clearly stated. The degree of specificity with which the producer describes the attitudes he wishes to engender, states the points of information he is trying to convey, or defines the objective he intends to accomplish, is related to the accuracy with which predictions can be made concerning the effects of his film on a given audience. Attitudes can be measured in the absence of such a statement, of course, but the task is more difficult, the results less directly applicable, and the outcome less certain.

2. The target audience is specified. Any viewer's perception of a film is the result of an interaction between the person and the stimuli he receives. Within any given segment of the population, differences between individuals are minimized and the members of an audience receive similar impressions of a film because they share similar backgrounds and experiences. In some other segment, however, the same film will give rise to another set of impressions, uniform but entirely different from the first because of the differences in experience and knowledge which the audience brought to the film. Little psychological sophistication is required to realize that a preproduction test of a training film conducted among eighth-grade girls will have little value in predicting its effectiveness for teaching Air Force Cadets.

3. The content is complex. It is immediately obvious that all films do not represent equal orders of complexity of content. The need for preproduction testing increases with the level of complexity, for the number of possible misinterpretations of highly complex or abstract material is greater than for simple and straightforward content. Since the purpose of such testing is to discover and correct these misinterpretations before they are included in the final version, the greater need for such testing of complex films is readily seen.

4. No precedent exists for content or method. When the content or objectives of a proposed film are similar to those of an existing one, a clever producer will profit by the experience of his predecessor; and if systematic data are available concerning the effects of the first film, his problem is further simplified. Experience, although of inestimable value, is not an adequate substitute for systematic analysis in drawing conclusions concerning effects. Generalizations from one film to another in this respect should be made with considerable caution. The need for preproduction testing is more urgent, however, when dealing with material for which no precedent in film making exists, or when the members of a production unit lack experience with a specific type or technique.

The Point at Which Pretesting Is to be Applied

One of the most difficult decisions to be made in planning a preproduction test is the selection of the stage in production at which it will be applied. Economy demands that it be applied early, for changes indicated by the results are most easily made during the planning stages of production; applicability demands that it be postponed, for the accuracy of the predictions increases as the form in which testing materials are presented approaches that of the finished film. The greatest profit is realized when preproduction testing is applied at that point which represents both the earliest stage in planning at which useful information may be obtained and the latest point at which changes in the film are practical.

The ideal test would be one in which an audience could examine a script or a treatment and describe their reaction to the finished film. This ideal is unfortunately unattainable for the same reason that an architect cannot predict how well his client will like living in a house for which he has seen only rough sketches or blueprints. The model does not represent the finished product with enough accuracy for the client to have the kinds of experiences he needs to make such a judgment.

The crucial decision of when to introduce the test is resolved to one of determining the earliest stage in production at which a sufficiently representative model of the finished film can be provided for the test audience. Experience has demonstrated that, in most cases, the story board is the earliest form with which persons unaccustomed to thinking in cinematic terms can make judgments which will be systematically and reliably related to their impressions of the finished film. Exceptions to such a rule inevitably occur; in some cases the nature of the content is such that a more advanced stage of production, a rough cut for example, will be needed to give useful results, while in others very valuable information about audience effects may be obtained by using narration without visuals. Experience in such testing and familiarity with the theory on which it is based are required to recognize exceptions to the general rule.

A fundamental difference which seems to characterize these exceptional situations is found in the relationship of the content and the nature of the symbols used, to the experience and backgrounds of the viewer. If the action or sequence to be presented in the film is very familiar to the viewer, then the static story board picture, or in some cases, no visual symbol at all, will suffice. When the process or event represented is not familiar to the viewer, or when the exact nature of the motion is crucially necessary to understanding the content, then a static symbol will not provide adequate representation of the intended process and story board or narration testing will not be sufficient. It is in these cases that reliable predictions of effectiveness cannot be made before the rough cut stage of production.

The Rationale of Preproduction Testing

This discussion may be best understood by placing the film in a communication context and examining it, and the practice of preproduction testing, in terms of known principles of communication theory. One of the basic principles of such theory is the distinction between one-way and two-way channels of communication. In one-way systems, which include motion pictures, a source (producer) transmits messages (content) to an interpreter (viewer) without ever receiving any messages in return. The source is always a source but never a receiver, and vice versa. A producer of educational films (message source) has no way of knowing if his audience (interpreter) makes ill-founded decisions or reaches erroneous conclusions on the basis of misunderstood or misinterpreted content. Any error of judgment on the part of the producer becomes and remains a part of the film because he who erred is not made aware of his error.

In a two-way system, the receiver may become a source of messages directed at the former transmitter, who now acts as an audience. Questions may be asked about misunderstood or misinterpreted portions of the original message and thus provision is made for correcting unexpected or unintended interpretations. The purpose of preproduction testing is to add this return channel and make a two-way communication system. By this process, the producer obtains "feedback" from his audience at a time when corrections and clarifications are not prohibitively expensive.

A discussion of any communication process involves consideration of four interrelated areas: the communicator, the content of his message, the audience, and the situation in which the communication occurs. In the case of a motion picture, the communicator is a group of persons; writers, directors, editors, and the like; the visual and auditory images of the film comprise the content; the audience is all the persons who see the film; and the situation is the physical, intellectual, emotional, and attitudinal climate in which the film is viewed.

The Communicator. To the preproduction tester, the most important consideration of the communicator is his intent (not to be confused with content). The process of creating symbolic material is never random or aimless; the communicator's selection is always governed by some purpose, implicit or explicit, which is related to the effects he wishes to create in the audience. Although some films may give another impression, any vehicle for symbolic material is a means-end system, and not an end in itself. The dilemma faced by the inexperienced producer in deciding what to put in his film may be escaped by deciding what effects he intends to create. The fact that the production of a motion picture is a cooperative endeavor creates a special problem in intent, a problem not encountered in other media. Unless each member of a production unit is aware of the intent of the film, and unless his own efforts are directed toward conveying that intent, the result is apt to be misunderstanding and confusion on the part of the audience.

The Content. So far as content is concerned, the basic task of the preproduction tester is to provide a model which, in as many of its significant aspects as possible, will faithfully resemble the finished product. The success of a preproduction test is dependent on the correct identification of these "significant aspects" and the accuracy with which models embodying them are prepared. If, for example, motion is a significant aspect of the content of a film and a test is conducted using story board sketches and narration, this aspect cannot be represented in the material presented to the test audience, and the information obtained will have little value in predicting effects of the final version, in which motion is present.

The Audience. In the whole bewildering chain of problems faced by film makers and students of the communication process, the most complex link is the audience. The producer who assumes that an audience is a passive static recipient of his film, or that the pictures he places on the screen become identical pictures in their minds, may find, to his own distress and enlightenment, that the effects he intended to achieve are not present.

The perception which any person forms of any stimulus is the result of an interaction between that stimulus and his own attitudes, experiences, knowledge, and motivations. Although no one can ever know what another person experiences, it is safe to assume that no two persons ever "see" the same thing in a film, even though they receive identical stimuli. The fact that similar impressions of a film are formed by several viewers indicates only that their backgrounds and psychological states at the time of viewing were similar. Each of us lives in a closed psychological field with his own interests, anxieties, motivations, needs, and value systems, and any external stimulus must pass through this "filter" and be altered by it before we evaluate or react to it.

It is because of this process of perceptual selection that we notice some things and ignore others, and it is because of the complexity of the process that assumptions regarding audiences or audience effects are hazardous. The escape that it offers the cautious producer from the necessity of making these assumptions is one of the more valuable features of preproduction testing.

The Situation. Although it has considerable theoretical significance, little that will be relevant to preproduction testing can be said regarding the relationship between the situation in which a symbol is observed, and the observer's perception of it. The effects of this variable are too frequently seen to be denied; the reaction of an operator of a carnival shooting gallery to a sudden loud sound, for example, differs greatly from the reaction of a soldier in combat to the same sound, and a picture popular in New York may be a dismal failure in Plainview, Kansas. Its usefulness in preproduction testing, however, is minimized by inability to exercise control over the physical environment in which such a test is made or the psychological predispositions of the audience.

Selection of an Audience for Test Purposes

Even if it were possible, it would be impractical for a producer to test all of the persons in his target audience; instead, he resorts to a sampling procedure to obtain a small group which resembles the target audience in those characteristics which are related to their reaction toward his film. In selecting this sample to represent the entire prospective audience, the tester is preparing a model of the audience in much the same way as he prepared a model of the content, and is subject to the same restrictions and limitations. If the model does not resemble the target audience in the characteristics deemed important, the result of the test will have little value. The ease with which these significant aspects of audience characteristics may be defined is related to the precision with which the target audience is specified. In testing a classroom film intended for sixth-grade pupils, the selection of a sample is relatively simple; a theatrical (Hollywood) production, however, intended for general distribution in a population varying in age, educational, vocational, temperamental, geographic, economic, and social levels, requires sampling procedures so complex and expensive that they represent a major obstacle to preproduction testing of such films.

The efficiency, and hence the value, of predictions of audience effect is proportional to the size of the sample tested and the amount of attention given its selection. Precise predictions may be made from preproduction tests if sample audiences are selected with proper regard for relevant criteria; gross approximations may be made on the basis of smaller samples selected with attention to fewer variables.

If preproduction testing is contemplated for a highly selected audience, the film maker may readily solve his own sampling problems with reasonable assurance of accuracy. If, however, the designated audience is heterogeneous, or believed to vary in several important characteristics, then the services of an industrial psychologist or market research specialist familiar with the more complex sampling procedures may be required.

Methods of Preproduction Testing

Not all preproduction tests are elaborate projects which utilize the services of a research team. This article, for example, was subjected to a "preproduction" test of a sort by submitting it to several readers unfamiliar with the field with a request for an evaluation of its clarity, and to others, experienced in such testing to be judged for comprehensiveness. Appreciable improvements may result if the members of a production unit re-examine their script and story board with consideration of intent and audience uppermost in their minds. If the services of a researcher are available, he may administer a test and, by applying purely intuitive criteria, examine his response material with the writer and director and be able to evaluate these responses in terms of their applicability to the film.

If testing is conducted at the story board stage of production, these sketches and a script may be used for testing small audiences. If many audiences are to be tested, or if a single audience is very large, it may be more practical to photograph the sketches and present them to the audience as a film strip, along with a tape recorded narration. When testing is to be carried out at the rough cut stage, the use of magnetic striped film is recommended because of the ease with which changes may be made in dialogue or commentary.

Methods of Measurement

If a target audience has been specified, the producer's intent stated, and a representative sample selected, there remains the problem of determining, quantitatively if possible, the response of the audience to the film. An estimate or measurement of the degree of attitude change or amount of learning is the crucial step in the testing process, for it is this information which will be compared with the producer's statement of intent to determine the effectiveness of the film.

It is necessary to return to the concept of intent in order to construct an appropriate measuring device, for the intent not only determines what the producer puts in his film, but also what the tester looks for in the audience. The ideal observation of effect is a behavioral one which may be quantified. For example, if a film is made for the purpose of reducing absenteeism among factory employees, a count of the number of man-days of absence in a certain period before the film is shown, and the number in a corresponding period after, provides an excellent measure of the effectiveness of the film in achieving this purpose. If different story boards were shown to matched groups, the one which brought about the larger decrease in absenteeism would represent the preferred approach for making the film.

In the absence of an opportunity to watch what people do, the next best procedure is to ask them what they intend to do, or have done. Most assessments of audience effects are, therefore, conducted by the use of interviews, questionnaires, and paper and pencil tests. The use of these procedures raises problems of motivating audiences to cooperate, determining the appropriate instrument to use and the proper questions to ask. Satisfactory solutions to these problems are based on specialized training, experience, and ingenuity, but in the hands of a clever and experienced person, such methods yield highly reliable and useful results.

Questionnaires may, in general, be divided into two categories, structured and unstructured. The former restricts the number and kind of answers that may be given to a question; for example, a statement might be made, "The main purpose of this film is to show the influence of low morale on production." The respondent may agree, disagree, or ignore the question, but no provision is made for any other response. This form of measurement is appropriate when dealing with concisely stated content, or with audiences who may be unable or unwilling to generate a response of their own. The unstructured questionnaire may take any of several forms; the most common one is the "open end" question. An example of such a question would, in the case just cited, be: "The main purpose of this film is . . . ." In this case, the respondent describes what he believes to be the principal purpose of the film in his own words, and at whatever length he deems appropriate. This form is preferred for those audiences whose motivation, cooperation, and verbal ability are such that they can create useful responses. It has the advantage of allowing for interpretations not anticipated by the test maker, and the disadvantage of being more difficult to interpret objectively.

Simple tests, questionnaires, and interviews may be planned and conducted by inexperienced persons and the results examined informally in their relation to the film. When large samples are used, or when the test or questionnaire is long, elaborate, or complex, the services of a psychological test maker may be required. The scaling, analysis, and interpretation of large quantities of test data is a difficult and highly specialized task.

The time at which a test is to be given is sometimes an important consideration in preproduction testing. Learning tests are sometimes conducted immediately after a showing, in other cases, when retention is a factor under investigation, an interval of time may be allowed to elapse before testing. Time is of even greater importance in measuring attitude changes; the nature of the content and the personality of the viewer are often such that a shift in attitude may be detectable only if the individual is given several days, or even weeks, to assimilate what he has been told, compare it with his previous attitudes, and restructure his value systems.

Summary and Conclusion

A showing, to a small audience, before production has begun, may be useful to give a film maker advance information about the reactions of an audience to his film. Such tests are most useful when used early in the process of production, but not before the material available for showing to the test audience bears a systematic resemblance to the finished film. In most cases, the story board is the earliest stage at which a film may be tested, although exceptions are found to this rule. Testing cannot be utilized unless the producer's intent and the target audience are specified, and is most apt to be profitable when the content is very complex or when the production unit has had no experience with a topic or technique. Useful information may be obtained by any alert producer, but if the target audience is heterogeneous or has not been clearly specified, or if precise and careful predictions are needed, the services of poll and survey specialists or a psychological test constructor should be sought.

The production of a motion picture, as anyone who has attempted it knows, involves a series of decisions. Preproduction testing may be viewed as a sort of "decision insurance" which, although it does not guarantee the desired outcomes, increases the probability of their occurrence.

NONLINEARITY IN FILMIC PRESENTATION

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Background

Human Variability

The essence of the nonlinear characteristics of the designer-interpreters of messages is their instability, their capacity for causing and for adjusting to change. One of the earliest and most provocative statements concerning the varying states of human awareness was made by William James. While discussing variations in the "changes of our mental content," James (45) wrote:

> As we take, in fact, a general view of the wonderful stream of our consciousness, what strikes us first is this different pace of its parts. Like a bird's life, it seems to be made of an alternation of flights and perchings. . . .
>
> Let us call the resting-places the "substantive parts," and the places of flight the "transitive parts," of the stream of thought. It then appears that the main end of our thinking is at all times the attainment of some other substantive part than the one from which we have just been dislodged. And we may say that the main use of the transitive parts is to lead us from one substantive conclusion to another.[1]

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[1] These remarks of James reflect, in turn, not only his own insights but also the current ideas of his period, for example: the concepts of the then emergent psychophysics of Weber (Pringle-Pattison,

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More recent and possibly more technical expressions of this variability have been made by engineering psychologists. These people have been particularly concerned with designing messages and machines for use by humans. In this regard, Biser (11) wrote, "The human operator, in the role of a control system, is highly variable, nonlinear, discontinuous and intermittent." In brief, wrote Belanger (8), "The human, from an engineering point-of-view is not a 'nice' system. It is nonlinear, it changes with time, it exhibits great variations between individuals."

When individuals gather into audiences, their collective variability may be assessed by means of profile analysis. Profiles of responses to the same message by several audiences were said by Twyford (84) to show "surprising concurrence." Similar concurrence, with even greater precision, is also evident in the very detailed codifications of human variability compiled for use in human engineering (91,7). Thus, even though the dimensions of response were principally subjective for Twyford's audiences (like-dislike, prediction of learning, clarity, goodness, etc.) and objective for the engineers (measures of anatomy, senses, performance, etc.), their results provide evidence for patterns of variability that have sufficient stability to be useful in both the design and the evaluation of messages.

Message Design

Film was the medium under examination in this study. Of interest, therefore, are attempts to manipulate that medium to better accommodate human variability--in particular, to adjust image size, number, or sequence to permit the viewer to respond more flexibly to the content of the film.

Format. Manipulation of the edges and relationships of filmed images has been fundamental to imaginative use of the film medium from its earliest applications in entertainment to its recent roles in education, propaganda, and industry. In his 1915 film Birth of a Nation, Griffith used an "iris" to introduce the key element of a scene as a small spot somewhere on the screen. He then gradually enlarged the spot to introduce additional elements, thus constructing a larger conception in which the initial element was central. A year later, his film Intolerance expanded the technique to include a variety of masks for directing audience attention to particular areas of the screen (44). By the mid-twenties, in the film, Napoleon, Abel Gance had separated the

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Andrew Seth. "Weber's Law." Encyclopaedia Britannica. Chicago: Encyclopaedia Britannica, 1947. Pp. 469-470; the original "Der Tastsinn und das Gemeingefuhl" was first published in 1846) and the consequent philosophical observations upon concrete duration and abstract time by Bergson (Bergson, Henri. Time and Free Will. New York: Harper & Bros., 1960; the original Essai sur les données immediates de la conscience was published in 1889).

screen into three permanent divisions. For emphasis, at points throughout the films, he projected parallel sequences on each of the screens simultaneously (76,51). Eastman Kodak, in the World's Fair of 1939, introduced a large-scale, three-screen display "Vitarama," thus further extending the concept of multi-image presentation (13,61). Apparently the idea was lost until 1947 when Life magazine capitalized on its pictorial prowess to develop "Picturama," a multi-imaged presentation of the American way of life. This traveling exhibit inspired the Seagram Distillers Corporation to develop possibly the first of what has become a standard in marketing, the traveling sales meeting that employs audiovisual devices for intensive delivery of concepts in merchandising. Seagram's "Vitarama" used live "drama" and five screens to illustrate distilling methods to salesmen (21).

In the fall of 1952, George Nelson, Charles Eames, and Alexander Girard conducted an "experiment" for the University of Georgia to demonstrate how the "industrial approach" could be used to teach art. They used motion pictures, tape recorders, three slide projectors, three screens, and a "collection of synthetic smells" to communicate "something specific--without loss of comprehension or retention" [italics theirs] (64).

In mid-decade, Disney Studios introduced a "Circarama" display for the American Motors exhibit in Disneyland Park, Anaheim, California. Using 11 screens arranged in a circle 40 feet in diameter and 8 feet off the floor, the exhibit presented pictorial and audible evidence of the pleasures of motor travel to a standing audience. The 16 mm filmed images were shot and projected synchronously (1).

About this same time, Glenn Alvey introduced his much-refined version of Griffith's "iris" in the film The Door in the Wall. Called the "Dynamic Frame," the system "allows the cameraman to choose any rectilinear composition and to vary it in time by graded steps during the scene to any other preselected size and proportion within the limits of the negative frame" (37,71). This approach permitted positive control of the viewer's access to specific or related elements on the screen, a control also exercised in multi-imaging when a single image or screen is used momentarily and then other diverse or closely related images are added.

By 1958, widespread interest in the use of film, in particular the multiscreen multi-image process, was evident in the Brussels Exposition. Mosby reported that "nearly every pavilion . . . has a movie theatre for exhibition of 'travelogues' relating to the beauties and accomplishments of its country" (63).

Eames, describing his 1959 multiscreen exhibition in Moscow, related his innovations to the picture magazine's speed of delivery and to its credibility.[2] He chose seven screens and "some 2,200 transpar-

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[2] Personal communication.

encies . . . to create an air of credibility" for what was displayed by the United States at the Exhibition (3). Also to be seen in Moscow at this time was Russia's "Kinopanarama," enlarged version of Disney's Circarama described above. The Russians used 22 screens arranged in two circular layers of 11 each; the lower screens were 12 feet high and 8½ feet above the floor, and the super screens, tipped at a 59° angle, rose some 13 feet above the lower screens. The whole array was over 90 feet in diameter and displayed a 20-minute sequence to a standing audience of 300 people (86). When viewing many images presented simultaneously, a Russian film critic pointed out, "the viewer becomes the author of the montage and directs his attention to those segments which interest him the most. . ." (4).

People in business and industry, meanwhile, were apparently impressed by the communicative potential of these exhibitions. Ford used a tent-housed traveling display as a "better way of taking our cars to the people." Its "Quadravision," designed to be set up in shopping-center parking lots, used four flanked screens in combination with live presentations and simultaneous action on all screens (30). Perhaps ultimate evidence for the ubiquity of interest by business and industry in these modes of presentation may be found in a special issue of Sales Management (77) devoted to communication in sales meetings. Seven articles in that issue include discussions of multi-image presentations.

In training and education, developments have been no less impressive. Since 1950, Teleprompter Corporation has been developing its five-screen "Telemation" technique for large-group instruction. As of July 16, 1962, this company listed some 90 military and government installations, including four "Presidential Briefing Rooms." Teleprompter's system is also being used at the university level for instructional purposes.[3] Eames used six screens to introduce science to visitors at the Seattle World's Fair (30). And, finally, perhaps the most novel extension of this approach to visual communication was developed by Kenneth Isaacs of the Illinois Institute of Technology. His "Matrix," a 12-foot, completely enclosed cube, used 24 slide projectors to project four images on each of six interior surfaces (88,42).

Clearly, in communication practice there has been considerable interest in the kind of variation in film format addressed by this study. One might see this interest as part of the never-ending search for novelty, and to some degree this is probably true. However, the rate and emphasis in these developments suggest that it is a search for greater efficiency in the delivery of messages, and that it has been discovered that humans can accommodate great quantities of information at relatively high rates of speed. As Nelson (64) saw it, in measuring success in his project, "the yardstick was a clock." Eames believes that "the number of levels of information that can be communicated is fantastic.[4] However, although human preference for this kind of complex experience seems evident, tolerance for it appears to be limited. Complexity, Berlyne (9) has pointed out, is preferred by humans who "have a tendency to fixate a part of the environment that is a relatively rich source of information in preference to one that is a relatively poor one." In the learning situation, on the other hand, there seems to be an adverse effect if complexity is increased beyond a "necessary minimum" (6). As Reed (72) put it, "The amount of effort to learn increases in almost a straight-line manner as complexity increases. . . . There is a definite trend to shift from logical to illogical learning."

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[3] Personal communication. [4] Personal communication.

Arnheim (5) has suggested that "neither the eye nor the mind is capable of taking in everything simultaneously," but rather that the "observer scans various areas of the picture in succession." Buswell (16) and Enoch (26) have demonstrated this point experimentally. Gombrich (32), too, has said that "reading a picture is a piecemeal affair that starts with random shots and gradually adjusts to the coherence of the work." Arnheim (5), who, unlike Gombrich, sees the message as central in this event system, has postulated the thematic structure of the image itself to be the organizing principle, one that is "comprehensible only when all the relationships it involves are grasped as being co-existent" (5). The resolution, then, seems to be implicit in the design of the message, a design that will satisfy the preferences of the observer, but that will not exceed his capacity for complexity. Even this capacity, Newman (65) has suggested, may be increased: "An individual in a particular environment will be most responsive to those stimuli that are more complex by some increment than his preferred level." He proposes the use of "pacer stimuli" that will force the subject's preferences to higher levels of complexity.

Content. Manipulation of the format of the stimulus films was also conducted along a dimension of increasing abstraction in the treatment of content. Both the visual and the verbal elements of the films were modified by "orders of abstraction" (50) ranging from precise reference to observable "things" of reality (53) to their symbolic and conceptual interpretations (52).

Interest in this dimension of human experience has been reflected in the variety of labels that have been attached to it. Perhaps the most familiar has been concrete to abstract (18,46,50), but there have been several others, particularly for the visual element: veridical to schematic (79), representational to nonrepresentational (5), iconic to noniconic (62,35), high-definition (HD) to low-definition (LD), and factual to conceptual (2,39).[5]

Along this same dimension of abstraction in the design of the films, verbal emphasis was distributed in much the same way as visual emphasis, from the factual to the conceptual, the denotative to the connotative (52), the descriptive to the interpretive and explanatory (49). At the factual end of the spectrum, although there could not be as direct a correspondence between the word and object as between photograph and object, the emphasis was referential, "concerned with setting forth the facts of the situation," describing the what of a process (8). At the other end of the spectrum, the conceptual emphasis in the films moved away from sense appearances in the direction of uniformities, predictable patterns, the how of a process. Conceptual in this context was used in the sense defined by Cohen (20): "Concepts are signs (mainly audible or visible words and symbols) pointing to invariant relations." Thus, in the sound track of the conceptual films an attempt was made to interpret and explain the physical processes that were only described in the factual versions and to provide a "conceptual pattern" for relating these processes to the generalized experience of the observers (33, 89,14).

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[5] Factual and conceptual were used by Allen, Hoban, and van Ormer to refer to types of knowledge.

Related Experiments

No reports of studies directly relevant to this combination of variables were found. The materials reported here have been drawn from diverse sources and have been fitted together into a pattern suggested by their content and relevance rather than by their continuity of development. It seemed appropriate, therefore, that these materials be partitioned according to their relationships to the factual and the conceptual variables.

Factual. As reported above, the Teleprompter Corporation has for a number of years been advocating and applying its five-screened "Telemation" system to information-conveying situations. Early in January of 1958, the Army Ordnance Guided Missile School initiated a series of evaluation studies of this approach in its training program (85). Ninety-six out of a total of 1,056 hours of instruction were conducted in this fashion, with one experimental and one control group in each of three 32-hour segments. Each segment emphasized different types of subject matter. The experimental delivery combined visual effects with scripted oral delivery. For approximately the same achievement scores, savings in instruction time varied from 19.5 percent to 41 percent. Surprise retention tests given nine weeks later showed a 4.7 point increment (total scores not reported) for the experimental groups. These preliminary results were reported when the study was 60 percent completed. Final results were not available for publication.

Perception of still images by children was of central concern in a series of studies carried out by Claude Malandin of the Centre de Recherches et d'Etudes pour la Diffusion du Français, St. Cloud, France. An early study (57) used a multi-imaged, four-by-four matrix (16 images) displayed as prints on paper and as a single transparency on a screen, with size and distance the principal differences. Each child was asked, in personal interview, to tell what he saw in the pictures. Children who had seen the images on paper "spontaneously viewed the images in the same order as they would read a text. But when the images were screened, the children did not feel compelled to view them in the same order, and, in fact, nearly a quarter of them failed to establish any orderly sequence. . . ."

In a second study, Malandin (55) investigated children's ability to interpret a series of graphic images. Each of 200 children in four primary classes saw three short, silent filmstrips, after which each child was asked to explain what he had seen. Then he had an opportunity to see and comment upon each frame separately. It was found that the younger children could not relate the successive images logically one to the other. Therefore, in conclusion, Malandin wrote:

> It would seem desirable to divide a story into two of three essential stages. The images relating to each one of these stages would be regrouped onto a single slide and projected simultaneously before being analyzed successively. The child could thus read the images at his own rhythm, take more time on the more difficult images, and go back. The disposition of the images side by side would help the child to establish logical links among the images.

To test this idea, Malandin (56) took one of the three filmstrips mentioned above and divided it into three groups of images: one group of four images, one of five, and one of two. Each of the 30 children, aged nine to eleven years, was shown the grouped frames twice. Each was then asked to relate what he had seen. Each then saw and commented upon individual frames. The results were compared to data collected in the series study reported above. Malandin found that "grouping the frames permits an increase in the number of recollections, but, above all, better organization of recollections." This difference decreased with age. Roshka (75) also found that "simultaneous presentation proves to be more effective than subsequent addition, especially with smaller children."

Conceptual. That films can teach both facts and concepts has been adequately demonstrated by studies reviewed by Allen (2) and by Hoban and van Ormer (39). No studies were reported, by these or other authors, that examined effectiveness of films depicting the same content treated in varying degrees of abstraction. However, several studies were found that were suggestive of what might affect the results of this experiment, even though they were conducted under somewhat different conditions and for different purposes.

Long and Welch (54) used both photographs and words, differing in level of abstraction, to study effects upon the abilities of children to generalize known principles. They concluded that "increasing the abstractness, either by varying the medium of presentation or by varying the hierarchy level, will affect adversely the child's ability to apply a principle of reasoning." They also found that this difficulty decreased with age.

In a study by Ismael, Puerto Rican children of the second, third, and sixth grades were shown three pictures, depicting exactly the same scene. "The children consistently chose the most realistic first, the next most realistic second, and the less realistic last." These two studies, and others with somewhat less relevance to the content variables being examined in this study, suggest that preferences for pictures and level of difficulty are related to the evolution of perceptual awareness characterized in the Malandin studies reported above (80,81,2,47). Preference and difficulty may simply be a function of readiness to perceive.

Discussion

Details of the experiment conducted within the context of these concepts were reported in the last issue of AVCR. Inasmuch as this was an exploratory study, it is believe that every effort should be made to penetrate its implicit objective, the clarification of requirements for effective design of informational messages. Toward this end, the following discussion of the experiment will include a critical evaluation of the study in an attempt to move beyond its procedural and statistical confines.

Message Design

Verbal Elements. The results of this study imply that contrary to recent revolutionary interests in multiple imagery and contrary to the insights reported by Malandin and others, there is really little cause for excitement. However, results showed that the difference between the nonlinear and linear formats for the sixth-grade groups barely missed significance at the .05 level and that this difference held up well in the delayed test. Also, the mean scores for these groups favored the nonlinear format in both the immediate and delayed tests. These differences become important, even though not significant statistically, when it is remembered that they were produced by variation in the visual component only. The scripts for each content pair of films (F:FC:C) were identical. Application of this control may thus have weakened the total visual impact of the films, but it served its purpose by isolating the effects of variation in visual format.

Strict controls were also imposed to relate the verbal to the visual content of the films--that is, the factual versions contained straightforward description of visual sequences, and conceptual versions contained interpretive explanations of the principles presented. However, the narrative style for each was essentially linear--that is, controls for comparability of verbal length, readability, accommodation of items in scenes, etc., imposed restraints on style that would not permit the language used to be as variable in its range of abstraction, its rate of change, or its continuity as the visuals used. Further, shifts in the factual-conceptual versions, where the abstract and concrete were mixed, reflected the consequences of these controls. Within the limits of the controls, an attempt was made to follow the prescription offered by Miller (60): "When trying to build up a general concept, it might be desirable to fade from one concrete example to the abstract representation, and then to a different concrete example, continuing the process until the main dimensions of variability were covered." However, because the possible variations in language were limited, it is postulated that a leveling effect was designed into the films through necessary controls on the narration.

Visual Elements. Each of the two types of formats that were compared in this study had advantages and disadvantages that appeared not to be equivalent in their effects. Malandin (55) found in his studies that the younger students could not relate one image to another if the images were isolated in time, that is, presented sequentially. Reed (73) found that simultaneous presentation permitted subjects to search for meaning among the stimuli, whereas serial presentation produced concentration "upon learning the names of the cards rather than working out their meaning." In addition to this consequence of the format used to deliver stimuli, their relevance to each other and to the desired response was also crucial. As Miller (60) put it:

> When cues from different modalities (or different cues within the same modality) are used simultaneously, they may either facilitate or interfere with each other. When the cues elicit the same responses simultaneously, or different responses in the proper succession, they should summate to yield increased effectiveness. When the cues elicit incompatible responses, they should produce conflict and interference.

Considerable care was taken in this study to achieve summation; however, success in this effort was not measured. Some indications did appear during the interviews to suggest that interference was operating in the nonlinear films. For example, several complaints were made that there were too many pictures and that difficulty was experienced in relating the flow charts to the pictures. Isolation in the linear films would tend to reduce this interference and thus favor this format (70,47).

In this regard, also, there may well have been problems in accommodating the scanning needs of those who saw the many images of the nonlinear versions. As Ely, Bowen, and Orlansky (25) put it, "The act of discrimination takes time: the more difficult the discrimination, the longer the time." Israeli (43) also concluded, "The more intricate the stimulus pattern, the longer the time required for perception of that pattern. . . . Longer time is necessary for integrative operations. This reflects effort and work in combining parts." Glanzer (31) reached similar conclusions in his discussion of the relationship between presentation rate and adaptation level, as that level moves from boredom to confusion. Also, Reed (73) pointed out that a certain minimum length for a given sequence was indicated: "In simultaneous presentation [of words], a certain minimum length of series is necessary to form correct concepts with an economical amount of effort. If the length of the series is below this minimum, the amount of work is greatly increased."

Along the content dimension of the study, results confirmed Carpenter's (17) "sign similarity hypothesis": "That films whose signals, signs, and symbols have high degrees of similarity ('iconicity') to the objects and situations which they represent will be more effective for most instructional purposes than films whose signals, signs, and symbols have low degrees of 'iconicity.'" Johnson (47), having reviewed the literature of concept formation as related to responses to complex patterns, concluded similarly that "conceptualization is therefore easier the more it resembles the perception of concrete objects." The low scores on the conceptual versions support this contention. However, Miller (60) suggests an alternative closer to the approach used in the present study.

> Often the actual object or piece of equipment may be too specific. We are interested in teaching a response which will generalize to a whole class of objects or situations. This generalization can be facilitated by using techniques, such as caricature and diagrammatic simplification, to emphasize the cues that are common to all of the members of the class, and to minimize or omit the cues that differ.

Experience in the present study indicates that facilitation of this order of generality is both desirable and feasible, but requires more than straightforward attention to cues, although cue control is certainly fundamental.

Verbal and Visual Combined. The composite message has its own characteristic requirements for effectiveness. These requirements pose difficulties of an intricacy second only to the problems of relating the message design to its individual user. Hartman (34) has provided an extensive review of these problems and of the relevant research to date. From his examination of studies of interchannel interference he concluded:

> . . . interference occurs when unrelated information is simultaneously presented and attention cannot be successfully alternated, and that it reduced the learning in both channels; that increasing the difficulty of the presented information results in increasing losses through interference; that when the information presented in the channels is of unequal difficulty, the less difficult information suffers the greater loss. . . . Interference may also be generated by adverse cognitive relationships in information.

One solution offered to these problems was to keep the level of difficulty "low enough to permit attention to alternate between channels" (34). However, if the desired result is elevation of the observer's ability in a particular subject or task at a reasonably efficient rate, then this solution is unduly restrictive.

In the present study, the images were selected and scripted for shooting on a frame-by-frame basis. However, limitations of available photographic imagery, difficulties of making equivalent graphic interpretation of processes, achievement of consistency in rates of change from film to film, and other controls applied to keep the films comparable experimentally tended to restrict the developmental freedom possible if only a single film were being developed. Means available for assessing the consequences of asynchronous variations in difficulty were gross at best, particularly for the graphic component. It was quite likely, therefore, that interchannel interference of the types described by Hartman were operating in the stimulus films. If this were true, then it would have been to the particular disadvantage of the nonlinear versions because of their multiplied image relationships--there would be a lag between presented verbal terms and available cumulated imagery (92)--and also to the disadvantage of the conceptual versions because of apparent difficulties in relating verbal terms to novel graphic symbols.

A second major characteristic of the composite verbal-visual message reflects a basic difference between the ways in which words and images codify and present reality. This particular difference was noted by Langer (52) as follows:

> Visual forms--lines, colors, proportions, etc.--are just as capable of articulation, i.e., of complex combination, as words. But the laws that govern this sort of articulation are altogether different from the laws of syntax that govern language. The most radical difference is that visual forms are not discursive. They do not present their constituents successively, but simultaneously, so that relations determining a visual structure are grasped in one act of vision. Their complexity, consequently, is not limited, as the complexity of discourse is limited, by what the mind can retain from the beginning of an apperceptive act to the end of it.

These distinctions raise interesting points concerning the effects of the types of messages studied in this experiment. Not only were all of the scripts essentially sequential in their delivery, but the multiple images also demanded clarity in their relational content to achieve optimal impact. The cumulative pattern of presentation in the nonlinear films plus the highly variable and at times incidental relevance of some images may have compromised the impact of an otherwise simultaneous presentation. Interestingly, this latter issue is debatable--the addition of a new image might be seen to have created a new and simultaneously presented set of relationships, or it might be seen as having been sequentially introduced into a static field--and without adequately detailed data this issue must remain debatable. Also, Langer assumes instantaneous perception of the visual image; whereas Buswell (16) has demonstrated that although the perceptual process is very rapid, it is still sequential. However, the scanning rate is sufficiently rapid not to invalidate Langer's basic point, and her distinctions lend considerable excitement to further inquiry.

Recommendations

Some implications of the experiment and the above discussion have been formalized below into a series of suggestions for further investigation. For convenience and interest, these formulations begin with the most general, move freely to particulars, and conclude with speculation.

Design Process

Possibly the most fruitful general class of studies that could be undertaken in the area of message design would be an examination of the design process itself, its logic and its products. Such a study would examine such things as the following: the assumptions commonly made, their patterns and relationships to intent and process; classes of objectives; expectations for control as related to concepts of optimum design, precision, and predictability; patterns of decisions as a function of time and other salient variables; classes of operational criteria used for selecting and mixing media; the "architecture" of the time-space message structure in a variety of existing message designs (*i.e.*,newspapers, drama, short story, speeches, technical reports, sales "pitches," advertising commercials in the several media, essays, briefings, military commands, and so on), always seeking the essential structure of the messages; and, finally, the design process itself in its totality and in the context of the communication event system. There are many well-known models of this event system, but none of the message-design subsystem, except as a very specific component of large-scale, message-producing organizations. There the models exist as part of the production or management control systems rather than as means for improving the message-design process itself.

Design Structure

If precision of effect is desired, then controls must be exercised in the design of the message to ensure flexibility of access that is adequate (within establishable tolerances) to accommodate the highly variable characteristics of the individual and grouped observer. To do this with a fixed message such as film, the designer must seek to control key elements in his design. This study found several such requirements for control to be of particular importance in this context.

Attention. Studies need to be undertaken that will codify the mechanisms available to the designer for managing the attention of the users of his informational messages. Relevant basic studies of attention need to be reviewed, integrated, and assessed as they relate to message design and structure. Analytical techniques need to be developed for optimizing shifts of attention between messages delivered through several channels at once. It is known that shifts in attention do occur; the problem thus becomes one of determining how to make the most of this trait (34,82,48,9).

It is further suggested that multimeasures be used to assess variations in attention for selected designs. In particular, two seem very promising. The first would use a real-time computer that would be central to both the criterion task and to one or more observers. The observers would note their observational tallies on multibuttoned keyboards coded to suit the expected responses. Both responses and tallies would then be processed appropriately by the computer and recorded at the time of occurrence for later interpretation. Also, estimates and interviews concerning the passage of time could be used as a means for relating psychological time to learning. It is postulated here that high attention levels would be accompanied by loss of awareness of the passage of time and hence in fact would result in wide ranges of attention span. It would be useful to know what kinds of message designs yield this effect.

Interference and Complexity. As was noted earlier, interference was thought to have played an undetermined role in the present study. Additional studies could be undertaken to develop a taxonomy of image interaction. One of the early problems in this area would be to develop a measure or measures of the concomitant effects of several variants of the multi-imaged format upon learning. Hartman (34) also calls for study of the "conditions governing . . . facilitation relationships . . . such as the success of a verbal label in improving the learning of an ambiguous drawing." Under what conditions do the relationships among images and words interfere or facilitate? Is there a predictable visual-verbal ratio perhaps related to the conceptual system of a given message (22)? What kinds of interactions (both in space and through time) increase complexity? What factors affect the limits of tolerance for complexity (65)? What are the relationships between rate and difficulty in the development of a message during presentation?

Development. Arnheim (5), in a discussion of choreography, reflects that "appearance is linked to definite phases of the total development, and different meaning goes with different locations in the perceptual sequence." Developmental structure is not a new idea by any means, but reconsideration of it would be timely in the light of modern means for delivering messages. Recent emphasis by Bruner (14) upon the importance of structure is suggestive here: "Perhaps the most basic thing that can be said about human memory, after a century of intensive research, is that unless detail is placed into a structural pattern, it is rapidly forgotten. . . ." Precisely what is the role of structure in relating message components to the needs of the learner, and what are the terms of that role in the new media?

The process of shifting one's frame of reference, one's point of view, one's set, is also of crucial relevance to message design (47,36, 9). In both the psychological and the physical time scales, development of the learning experience might be optimally controlled by precise placement of cues designed to shift the emotional and the logical frames of reference of the learner (69). The nonlinear response patterns of an observer of a film would make precision of predictive placement for any given individual doubtful; however, as was noted above, profile techniques offer at least a preliminary means for assessing optimum placement. Other measures might be rates of error, tolerance for speed of delivery, accommodation of varying content, and patterns evident in observed perceptual responses. It might be that interference intentionally introducing preceding crucial cues would help to develop readiness to recognize the crucial cue or set of cues. An appropriately designed multiple-image format might be used to introduce the interference by presenting apparently unrelated images that would be resolved by an isolated cue image; or, the reverse, a series of rapidly presented images in isolation, whose relationship would be reinforced by simultaneous summation.

The rate of both change and delivery may thus also be seen as an important dimension in the study of message design. Probably the limiting factor for either verbal or visual presentation would be the rate of scan for each channel. Study is needed here to determine more precisely the patterns of differential scanning rates for composite messages and thus to clarify the requirements for fitting both images and words to the variable characteristics of groups and individuals. Investigation may well show that effective use of composite messages will permit drastically increased input and processing rates and, when appropriately structured and paced, will more clearly define the effective role of graphic communication.

Flexibility. Most of the preceding recommendations have been made under the assumption that messages must first be designed, then produced, then delivered; in short, that they are a fixed unit or sequence of deliverable content embedded in an appropriate vehicle for delivery. The required "fit" to the acknowledged nonlinear variability of the human processor must be specified in detail, thus requiring elaborate and precise measurement or at least estimate of the elements of variability in advance. But why must the message be fixed? Why must the message be designed for the observer? What might be required to permit him to design his messages for himself, in real time, as his learning or speculative needs require? The specification here is not for a message with fixed logic, but for an adaptive, flexible, accessible source of raw or semiformulated information to be delivered precisely as required (28).

Among the traditional media, the criterion of flexibility would rate the textbook higher than the film as a medium--recognizing, of course, the different codification and scanning characteristics of the two media. The film might be made more flexible in use if combined either with novel projection facilities or with related media. For example, a short loop of film might be used as the carrier of the unit message; then, single frames from the film might be subsequently projected for discussion, using a random-access projector to permit immediate manipulation of the sequence of frames as desired by the teacher. The short film loop might then be shown again to reconstruct the now disassembled logic. Several quick passes through these images might well convey and confirm even the most difficult materials to the most restricted learners. But this still would be group instruction, and the real need is to accommodate individual variability, rapidly.

Computer-controlled access and delivery of information offers promising potential for providing radically improved fit of the message to the changing needs of the individual (29,23,15). These methods thrust into being both new possibilities and new demands. The rationale for message design developed above would shift emphasis from preassessment of the inherent nonlinearity of the human processor to current and continuing assessment; rate and precision of delivery would meet new standards; cue control would become a process of real-time sensing by the machine; interference and attention levels might also be assessed, and complexity levels might eventually be paced as proposed by Newman (65). The limiting factors in this approach seem to be machine capacity, codification and retrieval of the massively complex classes of information relevant here, and cost. Once these problems have been resolved--and there is clear promise of this (38,78,24,19)--there will quite likely follow a drastic revision in traditional thinking about strategies for learning. Flexibility of this order in message design may introduce the application of search and problem-solving models as central in the design of curricula and their supporting information systems (47,27,59,68). Retention of traditional subject matter may well remain the substance of the educational process, but the basic means as well as the goals will be enhancement of the individual's creative interaction with his informational environment.

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PART FIVE

MEDIA CONTENT AND OBJECTIVES

THE INSTRUCTIONAL GESTALT

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In recent years, higher education has become a subject of psychological research and thinking in a new and exciting way. The reasons for this resurgence of professional attention to educational problems are diverse. They include such factors as "cold war" competition for technological superiority, enrollment pressures generated within a democratic society with a high standard of living, material assistance for research in education from funds and foundations, and the inclinations of psychologists to help shape the development of a significant social institution.

A fairly typical pattern of investigation seems to thread its way through the fabric of educational research conducted by psychologists and others. This pattern is best characterized as comparative in nature, i.e., it compares the relative efficiency of two or more instructional techniques. The outcomes of this kind of investigation, with great uniformity, tend to be reports of nonsignificant differences.

The objectives of this paper are to (a) offer a critical appraisal of the "instructional comparisons" approach to studying the teaching-learning process; (b) propose a methodological framework (the Instructional Gestalt) suggesting a potentially more fertile research pattern; and (c) illustrate concretely the direction of research suggested by this framework.

A Critique of Instructional Comparisons

The fundamental objective of the "instructional comparisons" approach is to compare some innovation in instructional procedure with older, better established, more traditional, or "conventional" procedures for attaining the same objectives. Within the limitations imposed

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by measurement procedures, it is generally discovered that students learn about as much when exposed to one kind of instructional environment as they do from another. The absence of significant differences is reported with monotonous regularity. Such failures to refute the null hypothesis are often accompanied by a statement to the effect that the "Hawthorne effect" may have been responsible for the experimental group's behavior.

This research pattern is not, by any means, the only one used. Whether or not it is "typical" is a matter of semantics. Nevertheless, it continues to be reported with great frequency. The large number of relatively recent comparative studies of the effectiveness of televised and large-group instruction testifies to the degree of favor still accorded this methodological approach (4,13,16).

Three elements of the comparative research pattern are given critical consideration here: the criterion problem, assumptions about homogeneity and independence of conditions, and theoretical bases underlying the pattern. The effect of deficiencies in these three areas is to build into the research design the likelihood of producing rather pedestrian findings.

The Criterion Problem

The inappropriateness of the criteria of learning efficiency utilized in much educational research need not be labored here. The primary criterion measure most often used is derived from the course examination.

This criterion may be defended on the ground that since it satisfies the instructor as a basis for assigning grades, it reflects attainment of educational objectives to the satisfaction of researchers (4). This defense is a weak one indeed. The process whereby an instructor is brought to the point where he is able to specify his objectives in terms amenable to evaluation is a rather laborious one (2). It is unlikely that studies of relatively brief duration afford sufficient contact between instructor and researcher to permit specification and assessment of higher level cognitive processes as dependent variables. Evaluative data in the affective domain are even more generally neglected.

Somewhat less generally recognized or made explicit is the fact that even those course examinations measuring pertinent objectives are not well suited to serve as dependent variables for educational research. Student performance on these measures reflects the operation of many variables most of which are not controlled by the experimental design. Students, after all, operate under conditions of constraint compelling satisfactory examination performance not only in response to adequate instruction, but often in spite of inadequate instruction. They are sensitive to external pressures from parents, friends, graduation requirements, etc.

Furthermore, examination performance provides a delayed criterion for assessing instructional impact and hence is subject to considerable contamination. Thus certain students who never attend class (hence never experience the independent variable under consideration) may perform extremely well on course examinations by virtue of having access to comprehensive notes taken by a person who has attended class meetings.

These considerations have led Bloom (2) and Siegel and others (17) to argue for utilizing an immediately available criterion of student thinking *in situ* to supplement end-of-course measures.

Assumptions of Independence and Homogeneity

Comparisons between "mediated" (TV, radio, films, telephone, etc.) and conventional instruction implicitly tend to assume that the classroom procedures under study are uniform conditions sufficiently independent and homogeneous to permit their utilization as independent variables. However, it is apparent that these assumptions often are untenable, even when the usual experimental controls are exerted (9,10,11,12).

Attempts to establish independent learning environments as experimental and control conditions may fail because teachers do not always share the investigator's zeal for purity of design. Teachers who discover visual devices or modes of presentation enhancing the quality of their "experimental presentation" are justifiably eager to use these also in their "control sections." Although a basic methodological error, this source of contamination is difficult to control and undoubtedly, in some measure, contributes to the large percentage of nonsignificant differences.

The assumption of homogeneity within each of the instructional procedures undergoing comparison is critical to generalization beyond the specific samples in the investigation. Procedures superficially designated as "lecture," "televised," "independent-study," or "conventional" usually are treated as uniform independent variables. However, such uniformity obviously does not exist. "Conventional" classroom environments differ from one another, for example, with respect to number of students enrolled, amount and type of verbal interaction permitted or facilitated by the instructor, the "psychological atmosphere" generated during the class period, etc., as well as such obvious physical characteristics as room layout and hour at which the class is scheduled. Therefore, to designate a class as "conventional," and to use this group as a control for comparative purposes, is to place reliance upon a very gross kind of descriptive designation. The same criticism holds also for the gross designations applied to the various kinds of "experimental" procedures.

Inadequacy of Current Theory

The foregoing discussion points up the fact that educational research is too often conducted in the absence of a unifying conceptual framework. The resultant data are grossly descriptive, but indicate little of what occurs during the teaching-learning process. Controls too frequently are exerted over a few superficial and easily measured or classified variables (like class size or academic ability) at the expense of the complex nature of the educational process. This has negative implications both for the kinds of information such studies can be expected to yield and for the likelihood of contributing via them to anything approximating a theory of teaching-learning.

A low level of information yield must be anticipated because the gross nature of the conditions under investigation probably produces cancellation effects in group data. Instead of dealing with samples exposed to homogeneous and independent conditions, the comparisons involve samples exposed to treatments each of which is relatively heterogeneous. Thus, by collating data across samples for any treatment grossly designated as a particular kind of instructional environment, we may actually come close to approximating the distribution of data for the population of instructional treatments!

Any theory of classroom learning must be founded upon a more substantial base than that underlying the pattern of data collection described in the preceding paragraphs. The time is long overdue when investigators stop inquiring whether one mode of presentation is as good as another and undertake instead investigations of those conditions thought to optimize the realization of educational objectives under clearly specified and delimited conditions (15,5).

To do this requires increased precision in conceptualizing the purposes of education and the settings (or learning environments) that may be provided to accomplish these purposes. Although proportionately in the minority, several studies specifically focusing upon alternative procedures rather than existing products have been reported in the literature. Investigations of the relative effectiveness of presenting one versus both sides of an issue and of the advantage of audience participation (9) are noteworthy examples of this more precise and fertile approach.

The thrust of the present paper is to conceptualize educational settings in a broad framework suggesting directions for research and, ultimately, for theory. This framework is what we have chosen to term the Instructional Gestalt. It is presented below in its present rudimentary form.

The Instructional Gestalt

Bloom and others (2) have suggested three domains of educational objectives pertinent from an evaluative standpoint: cognitive, affective, and psychomotor. The psychomotor domain was rejected for taxonomical purposes because little is done about it in college teaching.

Disagreements about the relative importance of objectives within the cognitive and affective domains have significant implications for structuring learning environments. On the one hand, there is the traditional view of the university as an environment for transmitting knowledge. This is in sharp contrast with the view, reflecting a psychotherapeutic bias, that cognitive accomplishments without affective involvement have little or no significant influence on behavior (14). The former position suggests that the learner is a manipulatable object to whom something is done by the teacher and his resources. The latter stresses the importance of "independent discovery" and leads to a view of teaching and learning wherein teacher and learner reverse roles frequently and confortably. The distinction from the learner's point of view is between "being taught to" as opposed to "participation and involvement in."

As a rule, individual courses within a curriculum generally strike some sort of middle ground between these extremes. Large lecture (or televised) courses may tend more to be information dispensing in nature; seminar courses at an advanced level may tend more to encourage student involvement and participation. But even lecture courses vitally involve some students under some circumstances; and certain students under some circumstances remain personally uninvolved even in seminar classes.

This observation calls attention again to the problem of heterogeneity within such grossly designated conditions as "lecture," "seminar," "televised," or "conventional" classes. These designations are predicated primarily upon consideration of certain aspects of the physical environment in which the course is conducted, neglecting variations within each condition. Furthermore, gross comparisons between conditions so designated tend to neglect factors aside from the classroom environment that also bear upon teaching and learning.

In contrast, the Instructional Gestalt is broad in concept, embracing the full multiplicity and patterning of factors entering into the teaching-learning configuration. The Gestalt includes, but is not limited to, the classroom environments.

Hovland, Lumsdaine, and Sheffield (9) made a similar case for multivariable experimentation with particular reference to media research. They distinguished among "population," "film," and "external" variables and hypothesized that the impact of a single variable within any of these classes might be contingent upon the accompanying variables. This point has more recently been reemphasized by Lumsdaine (12).

It is precisely these kinds of interactions that we suspect are partly responsible for producing cancellation effects in mean performance comparisons between grossly described classroom groups. Hence the Instructional Gestalt framework focuses upon interactive analyses utilizing analyses of variance (or covariance) designs.

The selection of variables to be included in the conceptual framework involved four fundamental considerations: (a) Each of the variables may be expected legitimately, on the basis of previous research, to have some bearing upon at least one of the criteria of instructional effectiveness. (b) The variables must be measurable or amenable to categorization and classification. (c) The variables may be manipulated in either direct or indirect fashion. The direct manipulation of variables may involve alterations in classroom environments or techniques of presentation. The selection of students to receive certain kinds of instruction and of teachers to conduct certain kinds of classes constitute a kind of indirect manipulation. (d) There is reason to believe that these variables underlie what takes place in the Instructional Gestalt in a "fundamental" or "causative" fashion.

Four major classes of variables are included in the conceptual scheme: classroom environments, instructor variables, learner variables, and course variables.

1. Classroom Environments. These are defined by the physical setting and characteristics of the classroom and by the events of the class period. Some of the specific variables entering into the composition of the environment include (a) class size, (b) physical characteristics of the classroom, (c) the physical presence or absence of an "authority figure" maintaining discipline, taking attendance, etc., (d) the methods by and extent to which audiovisual devices of various kinds are utilized, and (e) the extent and level of participation by students in class activities.

It is readily apparent that gross classifications by environment, like "TV classes vs. conventional classes," provide for variations with respect to such variables. It is important to note, however, that different sections of any course designated by the same gross environmental classification (e.g., "TV class") may really constitute different environments.

2. Instructor Variables. The teacher's behavior both in and out of class constitute the "strategies and tactics of teaching." Whereas classroom environments describe the physical setting and structure provided for the course, the instructor variables describe the unique contribution made to a given classroom environment by the teacher. The teacher's operations that have been selected as particularly pertinent to the present conceptual scheme for the Instructional Gestalt are--

a. The instructional objectives manifested to his students by his behavior in class and by his examining procedures. Note that this variable is defined by classroom behavior rather than by the instructor's verbalizations to the investigator about his objectives. The teacher, for example, who maintains that he is attempting to stimulate critical thinking but who tests and grades only for rote recall actually reinforces rote memorization.

b. Amount and quality of personal contact between teacher and students. Instructors differ considerably in the extent to which they are interested in students as persons and derive genuine satisfaction from developing personal relationships with them. Some teachers actively seek personal contact with students, occasionally extending their influence beyond the confines of the classroom. Their students are more likely than those of "avoidant" teachers to sense a rapport with the instructor and to feel that they are personally known to him. "Avoidant" teachers perceive their role as limited to dispensing information or conducting in-class discussion in a rather impersonal fashion. They often do not learn the students' names and generally are rather unavailable to their students either in or out of class.

c. The intellectual climate developed by the instructor. Provision, or absence of provision, for classroom participation by students has been cited as one of the important variables in defining the structure of the classroom environment. Assuming an environment arranged to permit student participation, the instructor may use this structure to encourage "intellectually divergent" or "intellectually convergent" participation as poles on a continuum of intellectual climates (8).

In a "convergent" climate Ss may ask questions closely related to the immediate situation (lecture presentation, laboratory task, demonstration, etc.) with some assurance that their questions will be answered. The thrust of a convergent climate for interaction is to aid the student's comprehension of whatever tasks or knowledge are germane to the immediate classroom situation.

In an "intellectually divergent" climate, the student is reinforced for stating ideas and making intellectual discoveries. The instructor implementing this climate is not threatened by questions to which he does not have facile answers and which may only be tangentially related to his planned sequence for the class period. This kind of climate rewards such student behaviors as application, synthesis, perception of relationships, and creative problem solving.

3. Learner Variables. The students exposed to any combination of classroom environment and instructor variables are heterogeneous with respect to a large number of "learner variables." The ones selected as particularly pertinent to the Instructional Gestalt are the following: (a) A constellation of characteristics variously designated as intelligence, academic ability, scholastic aptitude, etc. (b) Knowledge about the subject matter prior to enrollment in a course. Such prior knowledge may have been obtained from courses previously taken or from readings of a general nature. (c) Motivation with respect to the specific course content. Why is the student taking the course? What significance does it have for him in terms of his vocational or personal objectives? (d) The student's set toward education. The extreme poles on the continuum of set may involve, on the one hand, a predisposition to accumulate isolated or specific facts and, on the other, a predisposition to attempt generalization by learning fact-clusters, developing concepts, and discovering principles. (e) Creativity in organizing his perceptual field and in solving problems.

4. Course Variables. Certain kinds of courses lend themselves more readily than others to particular kinds of structures (classroom environments) and instructor behaviors. This is true because courses differ in the kinds of students attracted to them, the kinds of instructors inter-

ested in teaching them, and the demands of the subject matter. Hence, at least three features of the course are important to the Instructional Gestalt: (a) the subject matter area, (b) the level of presentation (elementary or advanced), (c) whether the course is required or elected by the students.

This conception of the Instructional Gestalt provides a basis for comprehensive thought about the process of teaching and learning in terms of the interactions of four classes of variables. For any given course, the effects of various kinds of instruction can be conceptualized and empirically studied in relation to variations in the classroom environment, the characteristics of students, and the relevant activities of the instructor. The burden of investigation proceeding from this kind of framework is to discover combinations of student, instructor, environmental, and course variables optimizing desired educational outcomes. A schematic representation of the Instructional Gestalt involving dichotomized variables for a particular course is shown in Figure 1 on page 433.

It is apparent from the figure that this scheme focuses on the interactive nature of variables operating within the Instructional Gestalt as well as on main effects. By using a conceptual framework calling for an analysis of variance design, we are making explicit our expectation that the individual cell loadings are of greater potential significance for developing a theory of teaching-learning than are the summary loadings across cells.

Criteria

The criteria for estimating the educative impact of particular configurations within the Gestalt (*i.e.*, cell loadings) must be derived from some prior delineation of course objectives. Different interactions within the Gestalt are anticipated when its impact is assessed by measures of factual recall and of critical thinking. Unless the goals are clear in advance, there is no valid basis for studying outcomes.

One of the ultimate goals of effective education is to maximize each student's capacity for thinking critically and creatively (7). To implement this broad curricular objective, Bruner (3) emphasizes the importance of teaching about relationships (*i.e.*, "structure"), and Rogers (14) similarly emphasizes a "problem" orientation. Both emphases are alike in that they maximize educational gain for the student by a process of independent discovery founded upon intrinsic involvement.

It is evident that some instructional configurations are more appropriate to this objective than others. It has been demonstrated, for example, that students think more relevantly in discussion classes than in lecture classes (2). However, it is equally clear that practical exigencies often mitigate against utilization of the instructional configuration most appropriate to this objective. Hence, it is important to discover the limits of effectiveness of alternative instructional configurations in terms of a fairly broad range of criteria.

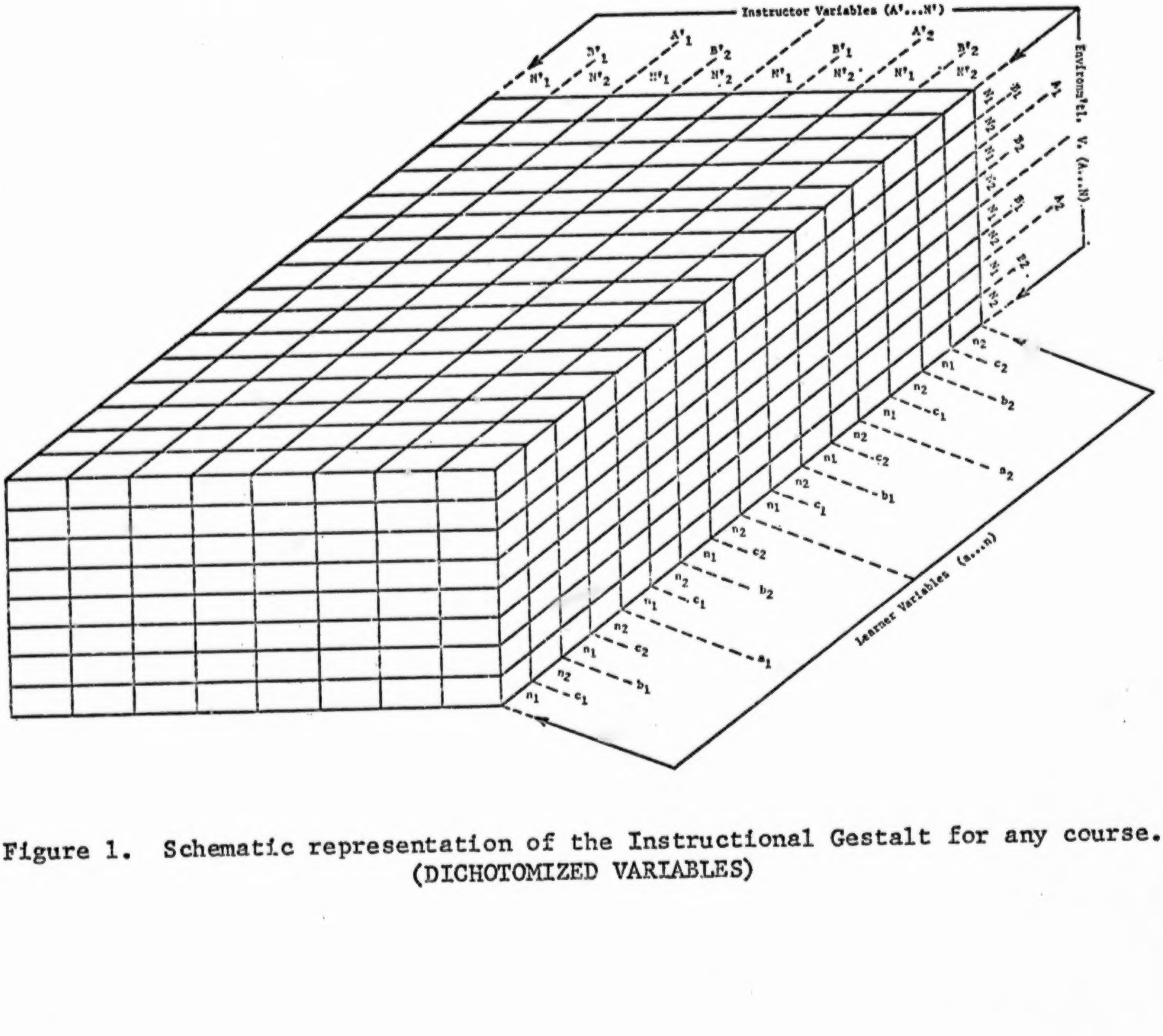

Instructor Variables (A'...N')
B'1
A'1
B'2
B'1
A'2
B'2
N'1
N'2
N'1
N'2
N'1
N'2
N'1
N'2
Environm'tl. V. (A...N)
A1
B1
B2
B1
A2
B2
N1
N2
N1
N2
N1
N2
N1
N2
Learner Variables (a...n)
n1
n2
c1
c2
b1
b2
a1
a2

Figure 1. Schematic representation of the Instructional Gestalt for any course.
(DICHOTOMIZED VARIABLES)

Six classes of student-oriented criteria have been selected as meaningful dependent variables for exploring the Instructional Gestalt. They are cited with the full realization that the list is not comprehensive. However, it does provide a broad base for evaluating the effectiveness of learning.

1. Acquisition and retention of factual information in the subject area. Factual information acquired is a criterion of some importance in assessing the educative impact of a particular course, even though it may occupy a relatively how position in the hierarchy of curricular objectives.

2. Acquisition and retention of concepts and the development of problem solving facility in the subject area. This criterion embodies some of the higher levels of cognitive accomplishment as outlined in the *Taxonomy* (2).

3. Quality of student thinking during the class period while the presentation is being made or the discussion is in progress. This is a unique criterion since it is obtained *in situ* rather than as a post-course measure. Reports of student thinking are systematically sampled at "critical points" in the presentation and are judged (*i.e.*, "weighted") for relevance of thinking. The scoring continuum extends from irrelevant thinking at one extreme through passive attention and simple comprehension to highly relevant thinking including attempts to apply information and synthesize. The general procedure was suggested by Bloom (2).

Reports of student thinking overcome certain of the objections raised earlier in this paper to end-of-course assessments. Such reports provide direct evidence concerning the cognitive functions stimulated by the Instructional Gestalt within a particular course and related to the ultimate objectives of higher education (15,17).

4. Development of course-related attitudes. These include changes in the affective domain desired as specific outcomes of the course under consideration. For example, we might anticipate that an elementary psychology course ought to produce certain attitudes concerning the appropriateness of scientific method applied to the social sciences, the sources of international tension, the status of psychology as a profession, etc.

5. Development of curriculum-related attitudes. Certain kinds of affective development or change may be anticipated as a result of the total curriculum rather than a single course. This development may involve changes in the students' self-perceptions and general approach to new or unfamiliar circumstances and problems. Although such development is most properly regarded as a curricular objective, it may be appropriate to define the "most effective" Instructional Gestalt for a given course as the one enabling that course to make a maximum contribution to the broader objectives of the curriculum.

6. Impact of the Gestalt upon the students' out-of-class activities, including such behavior as vocational choice, leisure reading, etc.

Values of the Scheme

The Instructional Gestalt is intended to be a systematic framework for asking useful questions. It has considerable potential for helping us organize some of the things we already know and generate hypotheses to fill some of the gaps in our knowledge. Most advantageous of all, it concentrates our attention on the basic teaching-learning process by making our concerns more pointed and sophisticated when we consider such instructional innovations as television, auto-instructional devices, and other products of our techological age as well as "conventional" teaching.

A Research Illustration

The specific research herein described is a portion of a larger exploration of the Instructional Gestalt operative in televised classes. Televised courses were chosen as a starting place for research upon the Gestalt for methodological reasons. It is possible, in such courses simultaneously to transmit the lecture emanating from a single source to a number of different classrooms. Then, by manipulating or arranging circumstances within each receiving room, it becomes feasible to explore various dimensions of the Gestalt under otherwise controlled conditions.

It is not anticipated that findings concerning the Instructional Gestalt in televised courses will be generalizable to the Instructional Gestalt in face-to-face settings. We regard the current series of investigations as exploring just those portions of the Gestalt pertinent to lecture-type instruction.

The series of investigations is being conducted in five different courses. The full matrix of independent variables explored in one course ("Foundations of Human Behavior") is shown in Figure 2. Since our intent for the remainder of this paper is simply to demonstrate the utility of the Instructional Gestalt as a methodological framework for educational research, the discussion is restricted to certain findings derived from the shaded portion of the matrix exhibited in Figure 2. This portion contains 64 of the 192 cells in the matrix for "Foundations of Human Behavior."

Subjects

All students enrolled in the course (N = approximately 400) were pretested during the first class meeting. The pretest battery consisted of the following instruments, all of which were developed for the current series of investigations.

1. Motivation Scale. A Thurstone type of scale designed to measure initial attitudes toward the course. Representative statements near the "favorable" pole are--

> 57. I believe I will learn more from this course than any other I am taking this semester.

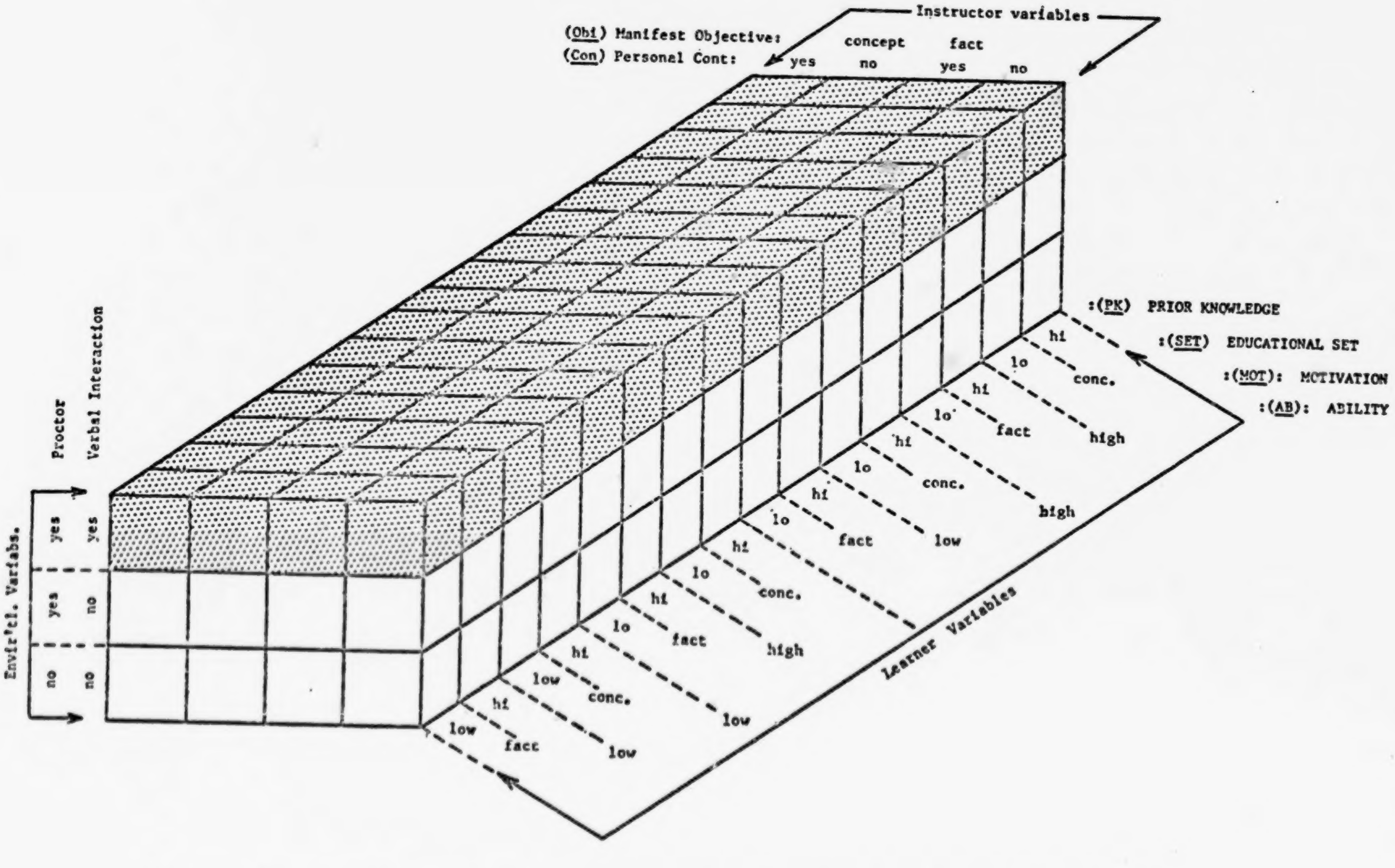

Instructor variables
(Obi) Manifest Objective:
(Con) Personal Cont:
concept
fact
yes
no
yes
no
Proctor
Verbal Interaction
Envir'tl. Variabs.
yes
yes
yes
no
no
no
:(PK) PRIOR KNOWLEDGE
:(SET) EDUCATIONAL SET
:(MOT): MOTIVATION
:(AB): ABILITY
hi
lo
hi
lo
hi
lo
hi
lo
hi
lo
hi
low
hi
low
conc.
fact
conc.
fact
conc.
fact
conc.
fact
high
high
low
high
low
low
Learner Variables

Figure 2. Design for investigating the Instructional Gestalt in "FOUNDATIONS OF HUMAN BEHAVIOR."

55. This course will help me realize my professional or vocational goal.

Two of the statements near the "unfavorable" pole are--

2. I wish I could have avoided taking this course.
5. I have no interest in this subject area.

2. Set Toward Education Scale. A forced-choice inventory yielding scores on a continuum characterized on the one hand by a predisposition to learn isolated facts and, on the other, by a predisposition to learn principles, relationships, fact clusters, and concepts.

The alternatives constituting each triad were paired on several different preference indexes including judgments about "how bright you have to be to learn this" and "the kind of impression knowing this would make on the naive person." One triad with its scoring weights will serve to illustrate the format of this inventory.

Items 70-72. Assume you are enrolled in a Natural Science course and must learn about the following. Which one will interest you most? Which one will interest you least?

Scoring			
Most	Least		
-1	+1	70.	The names of the elements included within the "halide" group.
0	0	71.	Statement of Newton's Third Law of Motion.
+1	-1	72.	The significance of a pH of 6.

3. Prior Knowledge Test. This test consisted of 20 multiple-choice items drawn from a previously administered final examination for the course. Its purpose was to distribute students along a continuum of initial level of sophistication relative to the course content.

In addition to the three instruments described above, ACT composite scores were available for all students since this test of academic ability is routinely administered to incoming freshmen.

The distribution of scores on these four measures were each trichotomized with scores at or below the thirtieth percentile designated "low" and those at or above the seventieth percentile designated "high." Every student enrolled in the course was assigned a categorical designation ("high," "middle," "low") for each of the Learner variables. Four sets of 16 critical Ss were identified to fulfill the Learner variable requirements within the Instructional Gestalt as shown in Figure 2. The placement of the four Ss fulfilling each S condition into specific viewing sections providing the required Instructor and Environmental conditions was randomly determined.

Thus, the study herein described utilized 64 Ss assigned to fulfill a 2^6 analysis of variance design with one case per cell. Since each viewing section was attended by approximately 60 students, only 16 of whom were Ss, it is unlikely that anyone other than the Es knew the identity of Ss.

Experimental Procedure

This particular televised course was transmitted to 12 different receiving rooms in order to effect the full matrix of Instructor and Environmental variables shown in Figure 2. Four of these rooms were structured to provide the Instructor and Environmental variables required by the portion of the design discussed in this illustration (shaded portion of Figure 2). All four rooms were proctored by an assistant during the formal televised presentation. Furthermore, Ss in these rooms were required to participate in a 30-minute discussion period following each 50-minute televised lecture.

Manipulations with respect to the Instructor variables were as follows:

1. Manifest Objectives. Three one-hour multiple-choice course examinations were administered during the semester. Two forms of each examination were developed. One of these forms, designed to manifest a factual objective, consisted solely of items judged to demand only rote recall for the factual content and principles presented in lectures and assigned readings. The other form manifested a conceptual objective by containing only items requiring students to apply factual information to a situation previously encountered or to synthesize and integrate factual information in some new way. The content coverage on the two forms are parallel.

The factual and conceptual forms of the examinations were each consistently administered to half of the Ss throughout the semester. The intent was to reinforce factual learning for half the Ss and conceptual learning for the other half.

2. Personal Contact. Two subgroups experienced no personal contact with the TV lecturer. Following each TV lecture, Ss in these groups participated in a 30-minute discussion period conducted by the assistant proctoring the section during the formal TV lecture. The two remaining subgroups experienced enforced personal contact with the TV lecturer since he personally conducted the discussion periods following his appearance on television. This "personal contact" condition was further reinforced by inviting only students from these groups to constitute student panels in the TV studio during the formal lectures.

A brief questionnaire administered at the end of the semester provided satisfactory evidence that every S in the "enforced personal contact" condition felt both that the instructor knew him and that he knew the instructor quite well. Conversely, all Ss in the "no personal contact" condition reported that they neither knew nor were known to the instructor.

The Criterion

The larger investigation from which the present study is drawn utilizes six criteria: two end-of-course achievement tests ("factual" and "conceptual"), two postcourse retention measures ("factual" and "conceptual"), and two *in situ* assessments of lecture impact ("attentiveness to presentation" and "relevance of thinking"). Since the present discussion is intended merely to be illustrative, we will present only data when the cells are loaded with scores on the test of end-of-course conceptual acquisition. These scores were obtained from performance on a subset of 74 items included within the final course examination. Each item required Ss to apply factual information or to synthesize and integrate it in some new way.

Results

The choice of an error term in an analysis of variance design with a single replication creates certain problems because of the absence of any estimate of experimental error corresponding to the mean square within treatments. One solution in this situation, discussed by Edwards (6), is to combine the higher order interactions as an estimate of experimental error. Accordingly, the error term for the analysis reported in Table 1 is a pooled mean square based upon the five-factor interactions (6 d.f.) and the six-factor interaction (1 d.f.). The 10 percent level of significance was selected because of the tendency to underestimate significance when some of the interactions constituting the error term are themselves significant.

TABLE 1

ANALYSIS OF VARIANCE: 2^6 DESIGN EXHIBITED IN FIGURE 2 CRITERION: "CONCEPTUAL ACQUISITION"

Source of Variation	M Square*	F
Obj: Manifest Objectives	72.25	4.46[a]
Con: Personal Contact	12.25	
Ab: Ability	1122.25	69.24[c]
Mot: Motivation	0.56	
Set: Set Toward Education	33.06	
PK: Prior Knowledge	132.25	8.16[b]
Obj x Con	42.25	
Obj x Ab	90.25	5.59[b]
Obj x Mot	10.56	
Obj x Set	14.06	
Obj x PK	9.00	
Con x Ab	4.00	
Con x Mot	27.56	
Con x Set	85.56	5.28[b]
Con x PK	100.00	6.17[b]
Ab x Mot	45.56	

TABLE 1--Continued

Source of Variation	M Square*	F
Ab x Set	27.56	
Ab x PK	110.25	6.80^{b}
Mot x Set	0.00	
Mot x PK	76.56	4.73^{a}
Set x PK	0.56	
Obj x Con x Ab	49.00	
Obj x Con x Mot	33.06	
Obj x Con x Set	33.06	
Obj x Con x PK	20.25	
Obj x Ab x Mot	14.06	
Obj x Ab x Set	7.56	
Obj x Ab x PK	100.00	6.17^{b}
Obj x Mot x Set	72.25	4.46^{a}
Obj x Mot x PK	0.06	
Obj x Set x PK	14.06	
Con x Ab x Mot	3.06	
Con x Ab x Set	10.56	
Con x Ab x PK	12.25	
Con x Mot x Set	58.25	3.60^{a}
Con x Mot x PK	33.06	
Con x Set x PK	3.06	
Ab x Mot x Set	0.25	
Ab x Mot x PK	22.56	
Ab x Set x PK	52.56	
Mot x Set x PK	9.00	
Obj x Con x Ab x Mot	27.56	
Obj x Con x Ab x Set	0.06	
Obj x Con x Ab x PK	49.00	
Obj x Con x Mot x Set	49.00	
Obj x Con x Mot x PK	1.81	
Obj x Con x Set x PK	0.56	
Obj x Ab x Mot x Set	4.00	
Obj x Ab x Mot x PK	33.06	
Obj x Ab x Set x PK	150.06	9.26^{b}
Obj x Mot x Set x PK	169.00	10.43^{b}
Con x Ab x Mot x Set	2.25	
Con x Ab x Mot x PK	0.56	
Con x Ab x Set x PK	3.06	
Con x Mot x Set x PK	9.00	
Ab x Mot x Set x PK	42.25	

Source	Sum Sq.	df	M Square
Error	113.37	7	16.20
Total	3267.75	63	

*Since df is always 1, the sum of squares is the same as the M square.

[a] $p < .10$

[b] $p < .05$

[c] $p < .01$

Significant Main Effects. Three variables--Manifest Objectives (Obj), Ability (Ab), and Prior Knowledge (PK)--give rise to significant main effects. Considered singly, these findings would be interpreted as meaning that criterion performance ("conceptual acquisition") is significantly better--

a. When the course examinations during the semester reinforce factual rather than nonfactual acquisition.

b. For high compared with low ability Ss.

c. For Ss initially sophisticated in the subject matter area compared with Ss originally naive in the subject matter area.

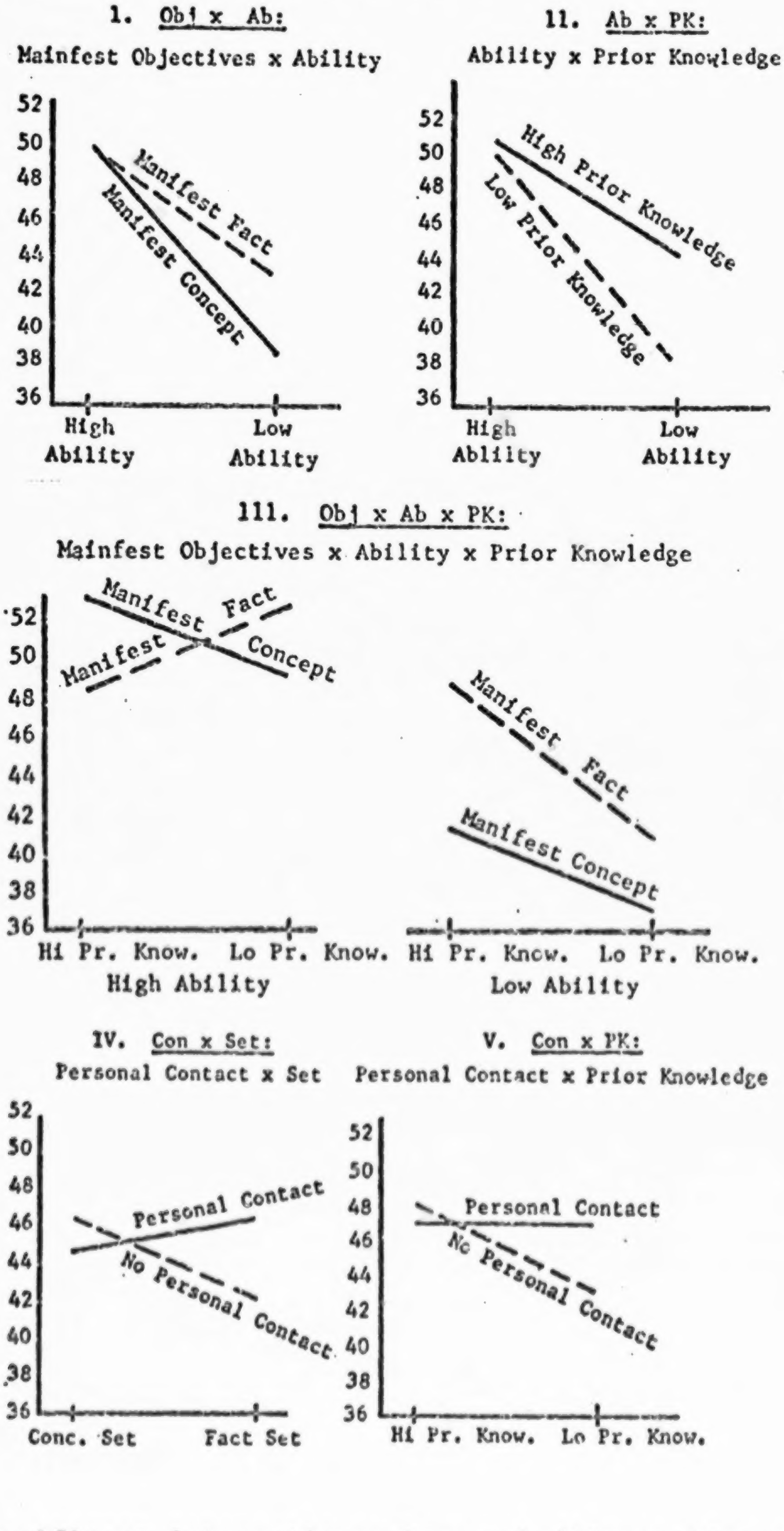
These findings are typical of those resulting from what we have previously referred to as "comparative" studies and could have been derived without recourse to the Instructional Gestalt framework.

Significant Interactions. One of the values of this framework is that it calls attention to interactions within the matrix, thereby adding substantially to the quality of information derived from educational research. These interactions are important in two ways: (a) when they involve variables with significant main effects, they permit a certain amount of refinement by establishing the limits of or mitigating circumstances affecting these variables; (b) when they involve variables not having significant main effects, they point to relationships that would have been overlooked in research of a "comparative" nature.

The significant interactions (involving either two or three variables) from the illustrative study are shown in Graphs 1-8 in Figure 3.

Three of these interactions involve only those variables that produced main effects. These are in interactions shown in Graph 1 (Obj x Ab: Manifest Objectives x Ability), Graph 2 (Ab x PK: Ability x Prior Knowledge), and Graph 3 (Obj x Ab x PK: Manifest Objectives x Ability x Prior Knowledge). These three interactions call attention to the often incomplete nature of interpretations based solely upon the discovery of significant main effects.

The main effect for Obj (Manifest Objectives) leads to the conclusion that for the group as a whole, criterion performance is enhanced when Ss are reinforced throughout the semester for learning the factual rather than the conceptual content of the course. Similarly, the main effect for PK (Prior Knowledge) leads to the conclusion that Ss originally sophisticated in the subject matter area demonstrate a higher level of conceptual acquisition at the end of the course than those initially unsophisticated in the subject area.



I. Obj x Ab: Mainfest Objectives x Ability

II. Ab x PK: Ability x Prior Knowledge

III. Obj x Ab x PK: Mainfest Objectives x Ability x Prior Knowledge

IV. Con x Set: Personal Contact x Set

V. Con x PK: Personal Contact x Prior Knowledge

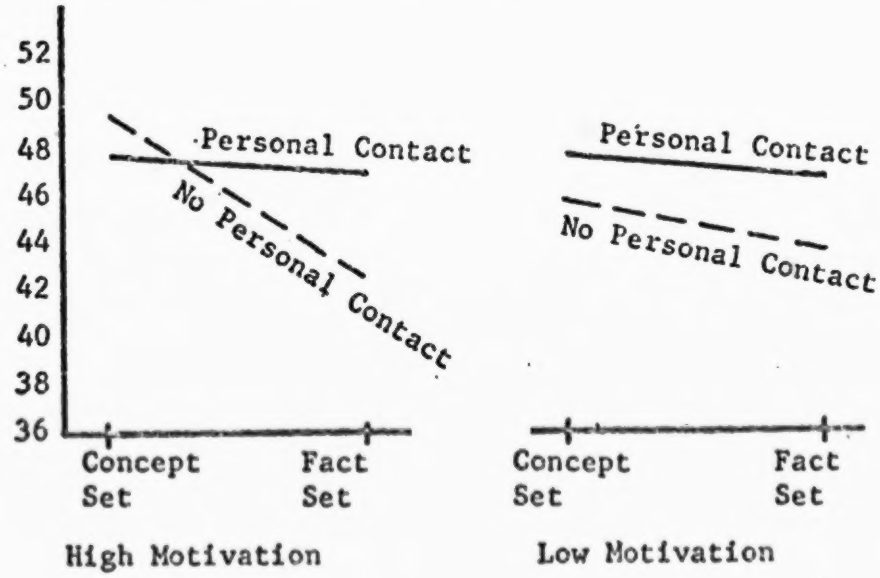
Figure 3. Significant interactions: Research illustration ordinate is mean score on criterion measure of conceptual illustration.

However, the two-variable interactions shown in Graphs 1 and 2 lead to modifications of the conclusions based solely upon the main effects. It is evident from Graph 1 (Obj x Ab: Manifest Objectives x Ability) that the differential effect of manifest objectives upon criterion performance favors reinforcement of factual learning only for the low ability Ss. High ability Ss are relatively unaffected by the kinds of learning reinforced throughout the semester.

The conclusion from the Ab x PK interaction (Ability x Prior Knowledge, Graph 2) parallels that for the Obj x Ab interaction. It is evident here that although level of initial sophistication is an important factor shaping criterion performance by low ability Ss, it has virtually no effect upon the criterion performance of high ability Ss.

VI. Con x Mot x Set:

Personal Contact x Motivation x Set



VII. Mot x PK

Motivation x Prior Knowledge

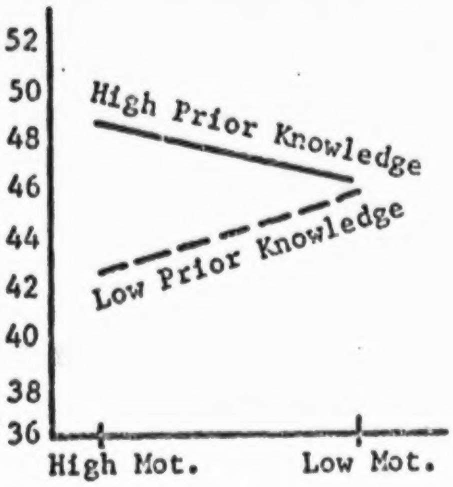


Figure 3--Continued

Thus at the level of two-variable interactions, the data lead to the conclusion that Obj (Manifest Objectives) and PK (Prior Knowledge) bear significantly upon criterion performance by low ability Ss, but not by high ability Ss. This differential effect of Obj and PK was masked by the main effects.

VIII. Obj x Mot x Set:
Manifest Objectives x Motivation x Set

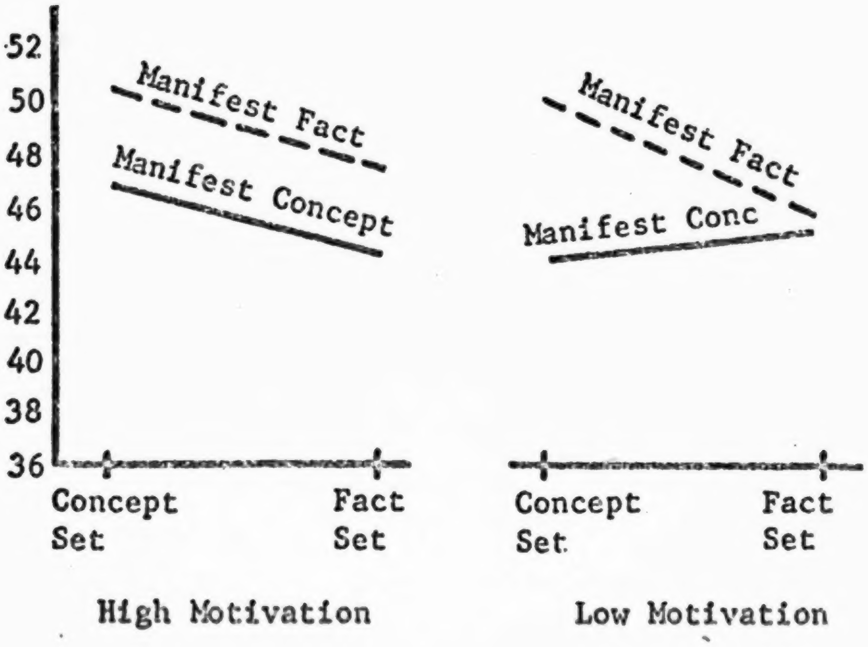


Figure 3--Continued

Further refinements in conclusions concerning the effect of these three variables upon conceptual acquisition follow from examination of the three-variable interaction shown in Graph 3 (Obj x Ab x PK: Manifest Objectives x Ability x Prior Knowledge). It is now evident that cancellation effects operated to produce those portions of the two-variable interactions concerning performance by high ability Ss. The manifest objective does indeed affect the level of conceptual acquisition by high ability Ss, but the direction of the effect is a function of a third variable--prior knowledge. Reinforcement for conceptual learning is particularly beneficial for high ability, initially sophisticated Ss; reinforcement for factual learning is particularly beneficial for high ability, initially unsophisticated Ss.

It is clear that analysis of the interactions between the three variables singly yielding significant main effects permits important refinements in conclusions about the import of these variables. Taken singly, the main effects produced by these variables masked the complexity of their interrelationships; and the two-variable interactions reflected cancellation effects. These masking and cancellation effects were overcome only when the three-variable interaction was plotted.

The importance of studying interactions in addition to main effects is emphasized also by the data relevant to Con (Personal Contact). The role of personal contact between student and instructor is particularly interesting in the light of evidence from a number of studies of large and televised instruction compared with small section or "conventional" instruction. Such studies often conclude with the inference that the presumed value of personal contact between student and instructor is generally overestimated, at least as it affects measured learning (4,16).

This inference, at first blush, appears to receive additional support from the present study because of the absence of a demonstrated main effect for Con. However, interactions Con x Set (Graph 4), Con x PK (Graph 5), and Con x Mot x Set (Graph 6) indicate that personal contact between student and instructor did influence conceptual learning by certain kinds of Ss. Personal contact facilitated (or lack of personal contact inhibited) conceptual acquisition by students who were initially poorly motivated, unsophisticated in the subject matter area, and predisposed to want to learn factual material rather than to apply and synthesize. Note, however, that personal contact did not influence criterion performance for initially sophisticated Ss or for those who entered the course with a "conceptual set."

These interactions involving Con reopen the issue of the importance of personal contact as a condition for classroom learning even in such a relatively impersonal instructional setting as that afforded by television. In perspective, the kind of personal contact provided by the design was contact in what we have earlier termed as "intellectually convergent" climate. It may well be that personal contact in an "intellectually divergent" climate would similarly benefit Ss who are conceptually set and/or initially sophisticated in the subject matter area.

The Role of the Instructional Gestalt in Framing Hypotheses

We stated earlier that the Instructional Gestalt is simply a conceptual framework for conducting research on teaching-learning. Its special virtue is derived from the fact that the framework calls attention to, rather than ignores or minimizes the importance of, the complex nature of the educational process. It focuses research interest upon variables in interaction rather than upon the main effects. Thus its principal values are that (a) it provides a systematic approach to asking an integrated series of research questions, (b) it produces a high informational yield from a given investigation or series of investigations, and (c) it enables the investigator simultaneously to view the impact of critical variables, taken singly and in interaction, upon multiple criteria of educational effectiveness under clearly specified conditions.

It remains for the investigator viewing these data to extrapolate generalizations. These generalizations must have the character, first, of hypotheses seemingly worthy of further investigation. Later, assuming research support for certain hypotheses suggested by explorations of the Instructional Gestalt, these hypotheses may with some confidence be taken as principles for inclusion in a theory of teaching-learning.

Some Hypotheses

We have already indicated that the illustrative study explored just a portion of the matrix constituting the Instructional Gestalt for the course in question (see Figure 2) and an even smaller portion of the matrix of instructional settings in general. Furthermore, for the purpose of illustration we utilized only cell loadings provided by an end-of-course measure of "conceptual acquisition" which we regard as (a) a somewhat contaminated criterion (see page 426) (b) standing in a hierarchy of educational objectives somewhat above simple factual acquisition, but considerably below such ultimate objectives as critical thinking and synthesis.

In view of these limitations, it is evident that our hypotheses are in a state of flux, undergoing continual refinement as data from explorations of increasingly larger segments of the Instructional Gestalt using more diverse criteria become available. However, it is possible, even on the strength of the very limited illustration, to indicate something of the nature of the generalizations toward which we are striving.

Hypothesis 1. Ss in formal classroom settings operate both in response to intrinsically and externally derived drives. The intrinsic forces are those commonly described as a "drive for learning" or a "desire to learn for the sake of learning." The externally derived drives include such things as the desire to (a) maintain grades, (b) be graduated, (c) gain approbation from parents, (d) be accepted by peers, (e) be accepted by teachers, etc.

Statement: The relative importance of intrinsically and externally derived drives is a function of the hierarchical position of the educational objective. For lower level objectives, both sources of motivation are equally effective. However, a discrepancy in effectiveness, favoring intrinsically derived drive, becomes increasingly apparent for objectives at progressively higher levels of the objective hierarchy.

Supporting Data: 1.1 The overall performance on a measure of "conceptual acquisition" ought to be similar for groups of Ss scoring near the poles (i.e., high and low) on a measure of "intrinsic motivation." (Supported by the absence of a main effect for Mot [Motivation].)

Supporting Data: 1.2 Intrinsically driven Ss should realize more effectively the objective of critical thinking in situ than should Ss scoring low on the measure of intrinsic drive. (Supported by data for Mot germane to this higher level objective, but not presented in the present paper.)

Hypothesis 2. Extrinsic sources of stimulation within the instructional setting may act in either of two ways: (a) The learner may regard them as pressures compelling performance. The emphasis here is on an external system of rewards and punishments. (b) They may contribute to providing an atmosphere wherein the learner becomes more actively involved with the subject matter. The former effect clearly operates for such extrinsic stimulants as tests, grades, etc. However, personal contact with the instructor as an extrinsic stimulant may have either or a combination of these effects.

The data now available are insufficient to delimit the conditions under which external forces act as "pressures" or as "stimulants increasing involvement." However, regardless of the operative mechanism, we can state the following as a hypothesis:

Statement: The performance level of poorly motivated Ss is enhanced in settings providing strong extrinsic stimulation.

Supporting Data: 2.1 An instructional setting providing enforced personal contact between teacher and student should facilitate learning by poorly motivated Ss. (Supported by that portion of the Con x Mot x Set interaction, Graph 6, showing the performance of poorly motivated Ss.)

Hypothesis 3. "Set toward education" has been posited as an important learner variable shaping the quality of S's behavior in an instructional setting. At the poles of the set continuum, factually set Ss are predisposed to learn isolated facts; conceptually set Ss are predisposed to learn principles, relationships, fact clusters, and concepts. At the present time, S's set is perceived to result, in part, from the type of reinforcement (*i.e.*, intrinsic or extrinsic) his past history has led him to expect.

Statement: In an intellectually convergent instructional climate, factually set Ss, more than conceptually set Ss, tend to be responsive to external sources of stimulation.

Supporting Data: 3.1 In an intellectually convergent climate, adverse effects in the absence of enforced personal contact with the instructor (an extrinsic source of stimulation) should be more pronounced for factually set than for conceptually set Ss. (Supported by the Con x Set interaction, Graph 4.)

Supporting Data: 3.2 Hypotheses 2 and 3 in combination imply that in an intellectually convergent climate, only Ss who are conceptually set and highly motivated should resist adverse effects due to the absence of enforced personal contact. (Supported by the Con x Mot x Set interaction, Graph 6.)

Hypothesis 4. Statement: The most effective learning environment for low ability Ss is one that reduces their perception of the likelihood of failure. In a general way, this implies that such Ss will perform best (a) when they perceive the learning objectives as being within the realm of attainability for them (i.e., the objectives stand relatively low in the objective hierarchy); (b) when the perceived risk of personal embarrassment from external forces (e.g., low grade, ridicule by peers or instructor, etc.) is minimal.

Supporting Data: 4.1 Low ability Ss should show proportionately better gains in knowledge when the course examinations administered during the semester reward factual (easier) learning rather than conceptual (harder) learning. (Supported by the Obj x AB and Obj x Ab x PK interactions in Graphs 1 and 3.)

Supporting Data: 4.2 The suitability of a highly interactive discussion environment for low ability Ss is expected to depend upon the degree of threat or acceptance generated within that environment (untested).

Hypothesis 5. Statement: The most effective learning environment for high ability Ss is one that provides an intellectual challenge appropriate both to their level of ability and to their level of initial sophistication in the subject area.

Possibilities for "challenge" were extremely limited in the illustrative study because it was conducted in an instructional setting occupying a very low position in the hierarchy of such settings. In spite of this restriction, the general hypothesis permits for certain deductions even within such a limited instructional framework.

Supporting Data: 5.1 A televised lecture setting in a freshman level survey-type course (i.e., a low-level instructional setting) ought to challenge high ability Ss differentially: the amount of effort expended by initially unsophisticated Ss ought to be greater than that expended by initially sophisticated Ss causing the former group to match the performance of the latter. (Supported by the Ab x PK interaction, Graph 2.)

Supporting Data: 5.2 High ability Ss initially sophisticated in the subject area should function especially well when reinforced throughout the semester for conceptual rather than factual learning. (Supported by the Obj x Ab x PK interaction, Graph 3.)

Supporting Data 5.3 High ability Ss should show proportionately greater gains in knowledge (and hold more favorable attitudes) when actively involved in an interactive discussion environment than when exposed to an environment (like that provided in most lecture courses) encouraging passivity. (This is untested in the present study. However, support for this deduction comes from studies previously reported by Macomber and Siegel [13].)

Summary

The argument is advanced in this paper that the pattern of educational investigation wherein comparisons are made between so-called "experimental" and "conventional" instructional procedures tends to be defective on three counts: the criteria are often inappropriate or contaminated; the assumptions of homogeneity within and independence between "experimental" and "control" conditions are met only when these conditions are very grossly conceived; and the results reflect masking and cancellation effects, thereby revealing relatively little about what transpires in an instructional setting.

The Instructional Gestalt is proposed as a methodological framework for educational research focusing upon the interactive nature of learner, instructor, and environmental and course variables constituting the instructional setting. Data generated by explorations within this framework can lead to the formulation of hypotheses which, if subsequently supported empirically, can become principles for inclusion in a theory of classroom learning.

The nature of investigations proceeding from the Instructional Gestalt framework was clarified by presentation and discussion of an illustrative study. Since this illustration was only a representation in miniature of the larger investigation, the generalizations about teaching-learning suggested by it are of limited scope and subject to change. Nevertheless, these generalizations do indicate the kinds of hypotheses resulting from studies within the Instructional Gestalt framework.

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SELECTING MEDIA FOR LEARNING OBJECTIVES

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Why Multi-Media Instruction?

The first of the above predicted outcomes (multi-media instruction) from applying the recommended system of analysis has been selected for special comment, as it is fundamental to the type of analysis proposed.

First, it may be said that while the spoken word and the printed word are, indeed, very important forms of instructional stimuli, they are not the most effective or economical teaching stimuli for many kinds of objectives. Graphic illustrations are a feature of most textbooks, and motions and space relations are better depicted (especially for young children) by three-dimensional models or motion pictures. Sounds other than speech need to be heard for many purposes--in music, mechanics, equipment operation. Thus, other forms of audio and visual stimuli are needed to supplement written and spoken words.

Second, in addition to selecting the sensory mode to be stimulated, verbally or otherwise, it is important to note that various educational objectives represent different kinds of learning, for each of which the external conditions of learning may be quite different (3,5). Gagne's treatment of this important concept forms a major aspect of the type of analysis recommended in this report.

Third, to supply the instructional events needed for each type of learning and to display instructional stimuli required in the sensory mode and quality needed, various media (audiovisual) devices are of differential effectiveness, depending upon the exact learning requirement imposed by the educational objective.

Excerpted from Instructional Media: A Procedure for the Design of Multi-Media Instruction, A Critical Review of Research, and Suggestions for Future Research. Palo Alto, Calif.: American Institutes for Research, October 1965. Final Report for Contract No. OE-5-16-011, Department of Health, Education, and Welfare, Office of Education, Title VII-B, National Defense Education Act of 1958. Pp. 17-29.

Fourth, there is sufficient knowledge (though yet very incomplete knowledge) as to the conditions required for the various kinds of learning, that this information, considered along with analysis of the instructional events and stimulus displays for each objective, can result in selection of a relevant instructional medium or media. These selections, translated into programing specifications, can result in the means for achieving improved effectiveness in learning.

It is important to note that as crucial as is the step of identifying the type of learning required by the objective, in order to specify the external conditions of learning, this step does not of itself lead to immediate choice of the medium. Many other factors, discussed later, are taken into consideration. For example, a necessary condition may be to provide contiguity between two stimuli; but identifying the sensory mode, and type, duration, and intensity of the two stimuli is also needed. It may then be apparent that any of several media may be able to present these stimuli in the particular manner needed to satisfy the instructional event required. It is due to the variety of stimuli needed primarily in auditory and visual modes (both verbal and nonverbal), upon which the requirement for multi-media instruction is based. However for some objectives, monitoring and correcting responses are also important.

In summary, multiple media are needed primarily to provide the range of displays needed, and to provide feedback and evaluation of responses. In total, the media are the means for providing stimuli, whether the stimuli are used to motivate, to direct attention, to set a goal, to give a prompt, to evaluate, to guide thinking, to evoke a response, or to test for transfer.

To summarize the above points, the central rationale for the proposed solution to the problem of how to choose instructional media rests on the assumption that various educational objectives require different kinds of learning. These kinds of learning, in turn, are established by different sets of conditions. The sets of conditions of learning in their turn, are made possible by the manipulation of instructional events. The way of providing or producing these instructional events is to apply appropriate stimuli. The sensory mode to be stimulated, and the detailed characteristics of the needed stimuli, together are considered in order to select the mechanisms or media to be employed to present the stimuli. Media are thus vehicles for stimulus presentation.

Examples of media include the teacher's voice, smile, or pat on the shoulder; books; charts; physical objects; pictures; sound tracks; TV; and sound-motion pictures. Such events as field trips and laboratory exercises are composed of exposure to one or more of these media for presenting stimuli. Once one specifies in detail the instructional events and the stimuli required, he is ready to choose from among several media by which the stimuli may be presented. Convenience, cost, and ease of switching from one medium to another are considered, along with other factors, in making the choice. The final choice is made with sequencing and packaging or programing factors in mind. These will be discussed in more detail later.

Many readers will be surprised by the heavy emphasis here placed upon stimulus displays as compared to the degree of emphasis upon responses by the student. Perhaps there are three reasons for this.

First, the external conditions of learning are those imposed by the teacher and all the other stimulating media to be employed. All that the teacher or the media can supply are stimuli, whether used to motivate or to prompt out a response. In short, instruction is composed of stimuli to provide the external conditions for learning. While a particular response is often desired of the student, the media can only provide the stimuli designed to evoke the response (these may include motivating, informative, prompting, and conditioned or unconditioned stimuli). Following the response (right, wrong, or withheld), the media can also provide feedback and evaluation. In contrast to the external conditions provided by the instruction, the student provides many internal conditions for effective learning. These may include pre-requisite skills already mastered and available as competencies to bring to the new learning situation. They may also include certain sets which serve to focus attention and effort and to seek certain kinds of rewards. These internal conditions of learning are provided by the student; the external conditions of learning are provided by the instruction (in the form of stimuli presented by many media).

Second, while agreeing that learning is an active process on the part of the student, and that no learning takes place without activity by the learner, the most important form of activity, in the opinion of the writer, is implicit and internal. To be more specific, this view is based upon the conditions of learning required by the types of learning most heavily represented in educational objectives, especially beyond the first or second grade. Categories one through four in Gagne's analysis (3), may require particular overt, explicitly-planned responses for learning to take place, as in learning by conditioning or shaping. But, as Gagne points out, learning of concepts, principles, and problem-solving can take place without the need to evoke particular responses from the student as an instructional event, provided that the student has access to feedback for his implicit efforts. And many of his efforts in these activities relate to recall, selection, and use of previously acquired competencies, whether in the form of a style of thinking or subordinate concepts. For these reasons, we deal with media as ways to present stimuli, rather than as ways to evoke particular responses which it is thought are necessary to the learning of the objective.

The view of learning presented here is thus one which implies that too much emphasis often is placed on a three-component theory of learning which consists of stimulus, response, and reinforcement. This paradigm is appropriate for learning which is accurately classified as shaping of behavior, but it appears less satisfactory for concept and other learning typical of school situations for children who have already learned to read. Further discussion of this particular point of view in terms of the nature of active responding in learning has been presented elsewhere (4).

To summarize, media provide stimulus displays and stimuli designed to serve various instructional functions, including feedback and evaluation. Teaching machines make more frequent and explicit use of feedback than do many other media from which students learn. This use of feedback following explicitly evoked overt responses is effective for some forms of learning, but is not a necessary condition for all forms (1). This kind of feedback, beyond its instructional value to the student, is often of value to the media developer in revising materials. Many important internal conditions provided by the learner are essentially independent from the instructional stimuli provided by media, but they are important factors in achieving particularly the "higher" types of learning among the types outlined by Gagne (3).

So far, the main justification for multi-media instruction has been stated in terms of ways to establish the various conditions of learning needed for various teaching objectives. There are at least three other possible bases for believing that multi-media instruction represents the best overall use of the individual media.

First, frequent changing of media may help prevent boredom and maintain interest and attention (2).

Second, there may be individual differences among students in the relative effectiveness of various media because of the specific characteristics of the stimuli used in the various media. Using a variety of media may improve the likelihood that each child will learn, even if this requires some redundancy in the various presentations. Since redundancy (repetition of stimuli) is a condition for some types of learning, it may be well in some cases to introduce the redundancy among media presentation rather than within a sequence for one medium.

Third, short of an absolute science of learning and instruction which would guarantee a way by which each child would master the objectives to a degree set by a standard, some justification exists for a "shotgun" approach. To the extent that our choices of media are faulty, use of several media in redundancy may be to some degree justified. However, consideration of this possibility need not overshadow the main effort to select the apparently best media for presenting the type of stimuli the analysis indicates to be desirable or required.

The end result of the proposed procedure would be production of small units of instruction which are grouped in such a way as to make use of one medium for an optimal time period, based on a trade-off between very brief exposure (to avoid boredom) and very long exposure (to make for economy in production and convenience in changing from medium to medium). In general, the goal is to cluster together elements of instruction for which the same medium would be effective in providing the needed conditions of learning. Some constraints will be placed on this clustering, however, by the logical structure of the subject matter and the process by which mastery of one objective establishes a pre-requisite for mastery of the next one.

Choosing Media vs. Improving Media

Why has research in educational media not already provided a procedure for the design of multi-media instruction? Apparently it is because most research has dealt with improving the techniques for developing a given medium (such as for making films) rather than with techniques for choosing media. While this research has brought sophistication in the process of developing these media, it has not in itself shown how to avoid inappropriate choices of media of presentation. Research has more often compared the effectiveness of alternate media than it has shown how to choose or use media effectively, either alone or in combinations.

A carpenter who makes good use of his tool kit does not attempt to drive nails with a saw, nor to measure levels with his brace and bit. He has been taught to use each tool for functions appropriate for it. Since it is fairly easy to specify the appropriate uses of each tool, the trained craftsman seldom uses a tool for an inappropriate purpose.

Unfortunately, the analogy of the carpenter's tool kit is more useful for stating our goal than for showing how the goal may be achieved. While the goal is to build multi-media programs of instruction, using at each step the most relevant medium, no simple set of rules can be stated to be followed in a cookbook fashion for deciding which medium is most relevant in a given instance. It is therefore *not* possible to train teachers or curriculum designers by use of such simple, always applicable, maxims as "for learning concepts use a teaching machine, and for learning to solve problems use a laboratory exercise." It is equally impossible to say that mathematics should be taught by programed instruction and science should be taught by audiovisual devices. It cannot even be said that all science concepts should be taught by any single medium. What *is* necessary is to say, "Given this behavioral objective and this pre-requisite repertoire of existing skills and knowledges, *this* concept may be taught by the following series of instructional events, for each of which any of several media could be applicable; let us examine the matter in more detail to see which is best to select, considering cost and convenience in terms of antecedent and subsequent objectives in our instructional sequence." The proposed procedure for the design of instruction is reached by the most painstaking analysis by which a match is obtained between objectives and media.

The main goal of the work, then, is to present some rationale or strategy by which a cirriculum designer could, like the carpenter, eventually succeed in choosing for each function to be performed, an acceptable and appropriate medium of instruction.

The further step to be taken is to plan to incorporate all the individual analyses of each instructional item and instructional function into convenient "packages" which permit some reasonable amount of use of the hammer before putting it aside to take up the saw. This problem of "how to change media rapidly" is crucial to the practical attainment of the goal.

Some alternate approaches to the improvement of the use of media other than by design of multi-media packages would be comparable to sharpening the tools in the kit. Continuing with the analogy, there is much prior research on how to make more effective films, or how to "program" a teaching machine so as to teach better or teach in a shorter time, to the neglect of research in how to match media to objectives.

The basis for the present decision to be concerned with the choice of media, rather than the improvement (sharpening) of a specific medium, rested partly upon the belief that present "sharpening" efforts are currently progressing more vigorously than is research in "choosing." It may also be true that from the present time onward the choice of media is in some respects a more important question since prior research has led to sharpening.

In summary, the proposed plan of operation rests on the hypothesis that media of instruction are now often developed on whatever topics interested the developer of various media, and that media are selected for classroom use in the absence of a definite rationale for the choices made, other than reference to the catalogs of what is available. The proposed plan is to devote analytical skill in matching media with objectives in order to specify the forms in which the instructional material should be presented. Then specialists in each medium can devote their skill where it will be most effective, making better use of all media, and relieving teachers of the need to sort through so many catalogs to select material. Most important, such a procedure is believed to be a potentially important factor in achieving the present goals of education.

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MEDIA AND TYPES OF LEARNING

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Characteristics of the Instructional Media

The key to the selection of the appropriate instructional media to use in any particular teaching situation is the relative effectiveness of that medium in accomplishing the desired educational objective.

In other words, given a specific instructional goal, what is the best means of reaching it? Interestingly enough, in education there is little experimental evidence to point the way for the making of these instructional decisions. This is true at every level of teaching and in every subject-matter area. It is true in the teaching of art, for example, and it is true in the application of audiovisual instructional media to the teaching process. Gagne and Bolles observed, "relatively little of a systematic nature is known about how to promote efficient learning in practical situations" (6). And Gage stated that "the limited usefulness of learning theory in education has long been acknowledged" (3). This does not mean, of course, that we know nothing about selecting appropriate media for instruction in specific tasks. It is just that this knowledge has not been systematically organized into a useable set of operational procedures that might be applied to the teaching of art.

Over the entire range of teaching you have, at different times, a variety of educational objectives. We will not argue the relative merits of the objectives in this paper, for this is the educator's responsibility, and the literature is filled with discussions of this problem. Our task here is to relate the audiovisual instructional media to the accomplishment of these various objectives. This is a difficult task and has never been systematically applied to instructional media selection for art education. So the following attempt must be treated as very tentative at this time. It is presented here in the hope that teachers will draw from it suggestions for instructional media implementation and not as a fully developed guideline to be arbitrarily applied to the se-

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Adapted from "Media Stimulus and Types of Learning," AV Instruction, XII (January 1967), 27-31.

lection of instructional materials. In Table 1 a very rough and preliminary rating is given for the effectiveness of different instructional media types when used to accomplish six different learning objectives. It is suggested that this evaluative grid be used jointly with the following explanation of the media-objectives relationships. Those teachers who want to obtain a more comprehensive background in the determination of learning objectives and their relationships to instructional techniques are referred to the writing of Gagne (4,5) and Mager (14).

Learning Factual Information

This includes information such as names, dates, events, terms, definitions, etc., all of which have concrete referents.

An abundance of audiovisual media research points to the effectiveness of films, filmstrips, television, and programed instruction in meeting this educational objective (1). Unfortunately, however, although the research indicates that these audiovisual materials are effective, it does not tell us specifically what types of audiovisual media are indicated under what kinds of teaching conditions. That is, we have no evidence that would help us choose from a variety of materials that particular instructional medium that would be most effective. At this stage of our knowledge, one might conclude that the use of films, projected still pictures, television, and programed instruction in the presentation of factual information adds little to student learning, and they are probably no more effective than such conventional types as print and oral presentation. On the other hand, films and projected still pictures do contribute greatly to the interest level of learners and provide a useful variety in the teaching. It should be pointed out that television is a carrier of information to the learner and probably possesses no particular characteristic that would make it more effective than any other instructional medium in teaching factual information. The characteristics of the television image are identical to that of sound motion picture image, but with significant degradation in picture quality. The educational differences between the sound motion picture and television are those related to the method of image display, the control that can be exercised by the teacher in using them, and the system of distribution of the images. From the standpoint of the teaching function, they appear to be the same. (However, Marshall McLuhan (15) would disagree, claiming that television is a different medium with different instructional characteristics just because of such features as degraded image and difference in display.) Research with programed instruction (17,18) indicates that factual information may be efficiently taught with teaching machines or programed textbooks, but not necessarily more so than with other instructional methods. The use of three-dimensional objects or demonstrations probably is of little instructional value in the learning of facts as such.

Learning Visual Identification

This learning task will involve the use of visual cues to discriminate one element from another and will require the identification and

TABLE 1

INSTRUCTIONAL MEDIA STIMULUS RELATIONSHIPS TO LEARNING OBJECTIVES

	LEARNING OBJECTIVES:					
INSTRUCTIONAL MEDIA TYPE:	Learning Factual Information	Learning Visual Identifications	Learning Principles, Concepts and Rules	Learning Procedures	Performing Skilled Perceptual-Motor Acts	Developing Desirable Attitudes, Opinions & Motivations
Still Pictures	Medium	HIGH	Medium	Medium	low	low
Motion Pictures	Medium	HIGH	HIGH	HIGH	Medium	Medium
Television	Medium	Medium	HIGH	Medium	low	Medium
3-D Objects	low	HIGH	low	low	low	low
Audio Recordings	Medium	low	low	Medium	low	Medium
Programed Instruction	Medium	Medium	Medium	HIGH	low	Medium
Demonstration	low	Medium	low	HIGH	Medium	Medium
Printed Textbooks	Medium	low	Medium	Medium	low	Medium
Oral Presentation	Medium	low	Medium	Medium	low	Medium

naming of objects, words, or symbols. This type of task is one of the most common performed by human beings.

It has been shown that in instructional situations where the initial presentation stimulus is similar to the performance or behavior in the final task to be learned, high positive transfer will occur (2,6,8, 12,16). It is to be expected that such a condition would prevail in the learning of visual discriminations in education. This means that the stimulus representations of the associations to be learned should be made as much like the stimuli in the performance or behavior in the final task as possible. It is apparent that conventional printed or lectured verbal stimuli have only symbolic similarity to visual identification learning tasks and would not be expected to transfer optimally to the final task situation. On the other hand, high amounts of positive transfer may be expected from pictured representations (such as films, slides, flat pictures) of stimulus objects where the final task performance requires crucial knowledge of these objects (7). The purpose of visuals of this kind is to practice, in the learning situation, the response needed in the performance situation. Gropper has called these "criterion visuals" because the "use of visual presentations appears to be desirable in those subject matters in which visually perceived physical objects and events are integral parts of the criterion situation" (9). That is, the learner should be able to observe, describe, interpret, or reconstruct the precise content presented in the instruction.

It would appear, then, that audiovisual instructional media that closely represent the physical characteristics of this material being taught should be effective in the teaching of visual discriminations. Those instructional media particularly high in this quality are sound motion picture films, filmstrips, slides, photographic illustrations, and three-dimensional objects. Interestingly enough, however, little audiovisual media research has looked specifically at this problem. Rather, the research has tested the effects of stimulus materials that have mixed objectives; thus, it is not possible to determine the specific relationships of the instructional media used to accomplish a specific objective. The best we can do at this point is to say that the theory strongly indicates that instructional media of a representational nature would be highly effective in the teaching of visual identifications.

Learning Principles, Concepts and Rules

This task involves the learning and understanding of relationships among things or events, the meaning of rules, or the principles pertaining to the functioning of different kinds of operations.

There is little experimental research with projected materials or television learning on this particular objective. However, a recent study by Gropper (10) used the programed instruction mode to study the learning of science concepts and principles on the basis of either visual (pictorial) or verbal (print) presentation alone. Gropper found that when a totally visual (pictorial) presentation of the concept to be learned preceded a verbal (print) presentation of the same concept, the learning was significantly greater and took significantly less learning time than when the verbal presentation preceded the visual one. The importance of this study, for our purposes here, are twofold. First, it represents a systematic attempt to develop a strategy of instructional media use by manipulating certain variables and controlling others to arrive at a generalizable conclusion. Second, it presents some very convincing evidence in support of the effectiveness of visual (pictorial) presentations.

Learning Procedures

This task involves learning to carry out a sequence of acts or operations in the proper order. There is no recognizable audiovisual research relating directly to this problem, but it might be expected that sound motion pictures, televised instruction, programed instruction, and demonstrations would be the educational media most apt to enhance such learning.

Performing Skilled Perceptual-Motor Acts

This task involves the use of simple and complex perceptual-motor skills for performing a manipulation task.

There is little doubt about the effectiveness of films in teaching perceptual-motor skills, particularly when students are given opportunities for active participation during the presentation process (1,11,13). Studies using the repetitive 8mm film-loop for skill training have demonstrated the efficacy of this promising instructional technique (19). For the art teacher who wishes to develop specific perceptual-motor skills and to give students an exemplary model to follow, there would appear to be a sound research base for the employment of motion picture films, particularly if they are used creatively (stopping for practice, repeating, etc.) rather than merely as one-way one-time communication media. If the teacher will use the repetitive 8mm film-loop and build in opportunity for student participation, skills learning will probably be greatly enhanced.

Developing Desirable Attitudes, Opinions, and Motivations

This task relates to the enhancement of the learner's preference for a particular point of view, idea, practice, or course of action, and requires the involvement of his drives, wishes, or needs. There is limited research evidence pointing to the superiority of any specific medium of instruction; but it would appear that a variety of different kinds of stimuli, presenting the learner with many dimensions of the subject, would be most likely to lead to the development of desirable attitudes.

Making Proper Use of Instructional Media in Teaching

In the previous section and in Table 1 some rough guidelines were presented as aids to the proper selection of instructional media under different conditions of learning. It is suggested that the following step-by-step procedure be used in order to make the most effective application of instructional media to art teaching:

1. State the exact behavior to be expected of the learner. In other words, as a result of your teaching of a specific lesson or sub-lesson, precisely what will the student be expected to learn or what skill to perform? This should be stated in very specific behavioral terms (5,14).

2. Identify the type of learning objective being met by the instruction. Descriptions of types as they relate to art education are presented in the preceding section. These types are also the column listings in Table 1.

3. Write down the particular "instructional event" that will occur (such as "Introduce the art materials for silk screen, printing" or "Demonstrate the procedure for silk screen printing"). From Table 1 select the appropriate instructional media options (such as "demonstration procedure" or "film of procedure").

4. Determine availability of the instructional media to meet the educational objective (from school materials, audiovisual catalogs, personal resources, etc.).

5. Determine availability of equipment needed for presentation of indicated material.

6. Arrange for preparation of unavailable instructional media and/or obtain access to needed equipment.

The preceding six steps may appear to be unnecessarily detailed, and the teacher, of course, will not be able to follow them for every lesson. They were presented, however, in the belief that if the teacher has a clear conception of his objectives and the behavior expected from his students, he will be able to make more intelligent media selections. This method substitutes a procedure that uses reasoned choice based on some set of standards for a procedure that operates merely on the basis of what materials are available. As a result, the quality of instruction should be improved.

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CONCEPT LEARNING

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Several variables have been systematically varied with results that suggest to the audiovisual field certain problems with which to concern themselves and certain procedures to follow as well as areas of further exploration. Some of these are:

1. An increase in the number of non-redundant relevant and irrelevant attributes and/or redundant irrelevant attributes which the learner must process increases the difficulty of learning the desired concept. The addition of redundant relevant dimensions increases the likelihood that the concept will be correctly identified. Simplications of the stimulus array seems justified in all cases except those in which essential information is removed. In many concepts, motion is not a relevant attribute, and it is questionable whether or not motion adds to the learning of such concepts. However, in some concepts, such as harmonic motion, the use of moving pictures is necessary to display the essential attributes of the concept. It is also true that some concepts, such as rhythm, do not need the visual channel at all. The addition of irrelevant information in any channel would tend to increase the difficulty of the task. It should be remembered, however, that many of the concepts learned under other than laboratory conditions are learned amidst a great quantity of irrelevant information, and that transfer might be facilitated under such conditions. This is an area that needs to be explored.

2. The type of strategy used by a subject is an individual matter, and one cannot conclude that all subjects will use the same strategy when confronted with the same situation. It is possible to affect the type of strategy used by a given subject by varying some or all of the factors which determine which strategy will be used. Some of these factors are: (a) the type of stimuli material, (b) the number of stimulus

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Excerpted from Research and Theory Related to Audiovisual Information Transmission. Revised Edition, 1967. U.S. Department of Health, Education and Welfare, Office of Education, Contract No. 3-20-003. Distributed by Western's Campus Bookstore, Western Michigan University, Kalamazoo, Michigan. Pp. 219-221.

variables, (c) the type of response required of the subject, (d) the relative cost of errors, (e) the number of tries allowed the subject, and (f) the instructions given. More research needs to be done looking into the question of how these factors and possible other factors effect the strategies used. Research is also needed to determine whether it is possible to control the strategies used by at least the bulk of the subjects or learners. The results and their application would be an added insurance that the audiovisual aid would achieve its desired purpose.

3. There are, apparently, limits to the amount of information a human can process. One must, therefore, either limit the amount of information contained in a stimulus array or series of such arrays, or one must code the information to be learned in a manner such as to make less demands upon the subject. By planning the sequence of displays and audio materials so that the learner does not have to keep track of many items of information, excessive cognitive strain can be avoided on the part of the subject. It might also be profitable in some instances to provide the learner with note taking materials and time for taking notes, or to provide him with a series of notes which would help him perform his task.

4. Positive exemplars result in the greatest amount of learning with the combination of positive and negative exemplars coming in second and the case of negative exemplars last. However, learning still takes place even in the case of negative exemplars alone. It is possible that with practice a subject could be taught to make more efficient usage of negative instances. Cues could be devised that would overcome the tendency on the part of subjects to fail to use negative information efficiently. More work needs to be done in this area.

5. Training using more different exemplars is more advantageous than training using fewer exemplars for a longer time. It is often the case with audiovisual aids that they provide only a very meager introduction to the various possible exemplars of any given class or category. It might be profitable to use some of the time allowed in an audiovisual presentation to acquaint the learner with more examples of the concept at hand.

6. One can control the stimuli to which a subject is attending much more efficiently when the stimulus array presented is stripped of all the irrelevant attributes. This would argue for less complex arrays with many of the now used embellishments being dropped. This control can also be greatly affected by instructions which point out the relevant attributes beforehand, or by adding a redundant dimension such as coloring the important parts of a visual display red. Correctional feedback also has the effect of limiting the amount of information in the stimulus array that the subject attends to. Several questions arise with respect to the use of cues and/or feedback. For example:

(a) If the attributes involved in the concept development task are visual, then should cues for identifying these attributes be auditory, or should they be visual (such as using arrows or the encircling of relevant features)?

(b) What should be the relationship between the cues of informative feedback and the presentation of the visual display? Presumably, cues should be given a few at a time or the learner may become overloaded with information.

(c) Another problem is the matter of the extent to which the learner should make decisions as a result of cues which may make the chances of errors very unlikely.

EFFECTIVENESS OF INSTRUCTIONAL FILMS

by William H. Allen

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* * *

The history of research in educational motion pictures is really the history of research in the field of audio-visual communication; for, until the more recent research in educational TV, the major research effort in AV has been with educational films. This research has been reviewed in detail by Hoban and van Ormer (13).

* * *

Knowledge of Facts. The evidence clearly supports the conclusion that films can teach factual information effectively over a wide range of subject matter content, age ranges, abilities, and conditions of use. This factual learning, however, tends to be rather specific to the information communicated by the film.

In early studies, Knowlton and Tilton (18), Holaday and Stoddard (14), Arnspiger (3), Consitt (7), Marchant (21), Watkins (33), Weber (34), and Wise (35) demonstrated the effectiveness of films in teaching factual information. During World War II, a series of studies were undertaken by the War Department to ascertain the effectiveness of training films. Hovland, Lumsdaine and Sheffield (15) showed that orientation films in the "Why We Fight" series had considerable influence on increasing solders' factual knowledge of the background of the war, the German war strategy, and the events of the so-called Battle of Britain. Meierhenry (22) reported that Nebraska high-school classes, devoting one-sixth of their instructional time in certain courses to an enrichment program with motion pictures, made significantly better scores than nonfilm classes on informational tests directly related to the content of the films and equal scores on national standardized tests. Wise (36) and Scott (28) found that learning tended to be specific to the material covered by films rather than general.

Excerpted from Audio-Visual Communication Research. Santa Monica, Calif.: System Development Corporation, September 20, 1958. Pp. 9-13.

VanderMeer (30) found that a body of factual information such as high-school general science could be taught by films along almost as effectively as by a teacher using conventional classroom procedures and even better if the films were introduced and supplemented by brief study guides. Anderson, Montgomery, and Ridgeway (1) compared the teaching of high-school biology (a) in the traditional textbook fashion with a minimum of laboratory work; (b) using 18 appropriate films to supplement the text materials but with no laboratory experiences; (c) using laboratory experiences, such as dissection and examination of specimens, but with no films; and (d) using films plus the laboratory methods. As measured by the Minnesota State Board Examination in Biology, the students in the combined film and laboratory group achieved significantly more factual information than those in the other three groups. Barry and Smith (4) investigated the merit of the Iowa Reading Films in teaching reading in Grade IX and found that the films themselves did not have significant effect upon learning. All experimental methods resulted in gains, probably due to the focused attention on reading and the increased motivation of students. Anderson and others (1) compared the teaching of high-school biology (a) without films, (b) by films used at intervals throughout the year, and (c) by films bolstered by emphasizing the principles stressed in each film. They found that the Films-with-Principles-Stressed method was somewhat superior to the Film method, which in turn was superior to the Conventional method. Romano (25) studied the role of instructional films and projected still pictures in teaching science vocabulary to intermediate grade students and found significant gains by the experimental over the control groups.

Perceptual-Motor Skills. There is little doubt about the effectiveness of films in teaching perceptual-motor skills. Studies by McClusky and McClusky (20) in teaching the construction of a reed mat and a pasteboard box; Freesman, Shaw and Walker (8) in teaching handwriting performance and position; and those by Priebe and Burton (24), Brown and Messersmith (5), and Lockhart (19) in teaching athletic skills demonstrated that instruction by film was at least as effective as by conventional methods.

VanderMeer (29) studied the use of eight U.S. Office of Education films in the training of lathe operators over a prolonged period and found that the use of films cut the working time, resulted in a reduction of the period of trial-and-error learning, and produced more factual information on machine operation. VanderMeer concluded that films are probably more effective in teaching the more complex skills than the simple ones. Hoban (12) reported a study by Beck and Lumsdaine which compared the teaching of the assembly and disassembly of a portable radar station with a film and with a competent instructor using a scale model. Although the two groups required about the same length of time to perform the operations when tested, the investigators concluded that the film instruction increased teamwork and efficiency.

Roshal (26) studied the effects of certain variables of learner representation on learning to tie knots and found (a) that a film is more effective if the task is portrayed from the viewing angle that would be assumed by the learner in performing the skill, and (b) that a presentation of the motions involved is more effective than presenting a series of static photographs. Two studies were made by Jaspen (16,17) on the effects of a number of film variables on learning the assembly of the breech block of the 40mm antiaircraft gun by naval trainees. An experimental film was able to teach 98 percent of the men how to assemble the breech block. Jaspen concluded that a slow rate of development, the pointing out of errors to be avoided, the repetition of the assembly demonstration, and the participation by the learner in the performance of the task contribute significantly to the effectiveness of the film. Harby (9,10) and Murnin, Hayes and Harby (23) used the daylight projection of repetitive film loops in the teaching of such athletic skills as tumbling and basketball free-throw shooting. They found that a repeated motion picture demonstration was at least as effective as a live instructor's demonstration, but that the live instruction was superior when the technique of individual coaching was added. Hirsch (11) reported that repetitive film loops taught rifle marksmanship skills to Army trainees as well as did the usual lecture-demonstration-application method. Zuckerman (37) pointed out that a medium level of verbalization (89-125 words per minute) and directive statements using the imperative mood in the spoken commentary were most effective in teaching naval trainees how to tie knots. VanderMeer and Cogswell (31) successfully used an Army training film to teach Army film projectionist trainees how to operate a motion picture projector. Cogswell (6) found that a three-dimensional film on the assembly of the breech block of the 40mm antiaircraft gun was no more effective in teaching the assembly skill than the two-dimensional film; however, the judgment of depth was not an essential cue to learning in this training situation.

Concepts. Although a frequent criticism of instructional films is that learning from them is "passive" and interferes with thinking and the development of concepts and inferences, there is no experimental research to support this negative supposition. On the contrary, the evidence is on the side of the film in developing concepts. Rulon (27) compared the learning from eight films in Grade VIII general science as it related to the learning of pure "rote" items and so-called "eductive" items which required the application of a concept or the inferring of one fact from another. He found that when films were added to instruction with textbooks alone, the eductive items were learned significantly better than the rote items as measured by both an immediate learning test and a retention test administered three and one-half months later. Vernon's (32) study with a sound film and silent filmstrip in teaching British seaman trainees to take soundings with a lead line and a Kelvin sounding machine showed that the film and filmstrip produced a greater gain in the "comprehension" scores than in the "memory for detail" scores.

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INFLUENCING MOTIVATIONS, ATTITUDES AND OPINIONS

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* * *

Influence of Films on Academic Motivation and Behavior

Some evidence exists that both entertainment and classroom films exert an influence on behavior which is valued academically. Furthermore, there is no evidence that motion pictures reduce academic motivation, that is, that they result in less voluntary reading, less voluntary participation in classroom recitation, or greater avoidance of a specific course of study.

Theoretically, at least, such influence as films may have on academic motivation is likely to arise from the nature of motion pictures and the context of instruction. Pictures are perceived in much the same way as situations and actions are visually perceived, that is, with no intervening intellectual skill, such as reading, operating either to facilitate or to obstruct perception. The experience derived from a motion picture facilitates further communication in the same general content area. This facilitation enables the individual to behave in ways which are socially approved in school and college.

Movies Offer Means of Attaining Goals

Academically approved behavior is reinforced by social approval of the middle-class family, which constitutes an appreciable majority in the American social structure. To the extent that the individual accepts academic (and intellectual) achievement as a condition of self-realization and to the extent that social approval enhances his self-regard, motion

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Excerpted from Instructional Film Research: 1918-1950. Technical Report No. SDC 269-7-19, Instructional Film Research Program, Pennsylvania State University. Port Washington, L.I., N.Y.: Special Devices Center, U.S. Office of Naval Research, 1950. Pp. 5.12, 5.18, 5.20.

pictures which facilitate intellectual activity and enable the individual to behave in socially-approved ways are a useful tool in the attainment of basic goals, and in the approach to a culturally defined condition, or state, of happiness.

The relationship between entertainment movie attendance and reading noted by May and Shuttleworth (1933) and by Lazarsfeld and Kendall (1948) may be viewed in somewhat this same light, except that, in this case, self-realization and self-regard are probably increased when the individual projects and identifies himself with the protagonists and situations in the movies and the magazines. In either case, movies appear to be a means to the gratification of personality needs, and appear to be positively correlated with the amount, and probably the kind, of reading. There is no evidence in research studies that movies take the place of reading, assuming that reading and movies serve somewhat the same functions for the individual.

Influence of Films and Other Media on Military Motivation

The studies cited point up the difficulty of modifying military motivation within the American culture. There is little exact evidence that films, as a medium of communication, can modify actual conduct motivations, if the desired motivations are contrary to those presumably developed by personal experiences and the vicissitudes of daily living.

Some of the evidence does indicate that films tend to reinforce motivations which are consistent with the milieu of daily life and with the aspirations of the individual or the social group of which the individual is a part.

Thus, we have, as a very moot and open question, the problem as to what extent one can hope, by using information and attempting to work upon the opinions of recruits, to bring about rather sudden changes in their motivation concerned with accepting the role of a soldier, which, in itself, is not highly valued in the American culture. There is no warrior cult in the United States.

* * *

Influence on Specific Attitudes

The following conclusions about the influence of films on specific attitudes (closely related to the film content) are justified from the Thurstone and Peterson study:

1. Specific attitude changes can result from certain motion pictures whose content is closely related to the object of the specific attitude.

2. The effect of motion pictures on specific attitudes can be cumulative for two or more films on the same social theme. The cumulative

effect may result even though some films in the sequence may be individually ineffective in reliably influencing a specific attitude.

3. When the initial influence of one or more motion pictures on a specific attitude is large and of high reliability, it may persist for several weeks or months, generally, although not necessarily, with some diminution.

. . . Few, if any, specific attitude changes will result when the film bias is strongly contradictory to the social norms. In the case of contradictory influences, film bias may actually reinforce the existing attitude, rather than modify it.

. . . Films may not exert the same attitudinal influence within a nonuniform population, such as one in which different occupational, social, or educational backgrounds are represented.

Influence on General Attitudes

There are several conclusions, largely tentative, which may be inferred from the experimental evidence on the influence of specific motion pictures on general attitudes:

1. The attitudinal influences of a single motion picture appear to be specific, rather than general.

2. The cumulative effect of a series of motion pictures is probably general, but the effect is subject to the following conditions:

a. The films are all biased in the same direction and are consistent with the general predisposition of the audience.

b. They are exhibited in a context that supports and reinforces the direction of the bias.

c. The exhibition of the films is spaced over a period of time.

There is, however, no direct evidence that motion pictures are reliably superior to other media of communication in their influence on general attitudes. Some evidence exists to the contrary. If the conclusions regarding the impact of films on the learning of information could be generalized to attitudes (and there is no evidence to support such generalization), it might be postulated that the force of motion pictures on general attitudes may be greater than that of verbal media alone, when the influence is measured in long-term effects and when conditions required in the development of general attitudes are satisfied. This postulate is somewhat feasible when reminiscent effect is taken into consideration, and when a relationship between specific and general attitude is assumed. However, research is needed on the long-term attitudinal effects of films to substantiate this postulate.

Variables Modify Film Influence on Opinions

The data on the influences of motion pictures on opinions appear to be in accord with the conclusions which may be drawn from previous attitude studies. These data serve to emphasize that film influence on opinions can be modified by a number of variables. In general, these variables are problems concerning the difference in effects on specific and general opinions; the length of time the influence persists; the way attitudes change with time; and the nature of intervening processes involved in this change.

Related to the processes involved in opinion changes with time is the predisposition hypothesis of Hovland, Lumsdaine, and Sheffield (they say that retention may be influenced by an initial tendency to accept the opinion).

This hypothesis is consistent with our hypothesis regarding the influences of films on motivation, namely, that specific motion pictures are perhaps more effective in stimulating or reinforcing existing motives than in reorganizing these motives.

. . . The data assembled on the influences of motion pictures on motivation, attitudes, and opinions achieve a consistency when examined in terms of the general concepts briefly sketched in the introduction to this chapter. The general principles which appear to apply to the effectiveness of films in influencing conduct motivation seem also to apply to their effects on verbally expressed attitudes and opinions.

Audience Characteristics Influence Film Effectiveness

In light of the research data and psychological theory, it is becoming increasingly evident that the ability of any medium of communication, including motion pictures, to modify motivation, attitudes, and opinions lies not so much in the medium itself, but in the relationship of the content and bias of the medium to (1) the personality structure of the perceiving individuals, and (2) the social environment of the audience.

Any medium of communication is exactly that--a medium of communication. In the process of communication the role of a communicator is not to impress his interpretation of experience on an audience. Rather, it involves the reaction of the audience to the communicator's interpretation of experience which he transmits by means of symbols. Hence, the content of communication, the audience predisposition, and the social milieu must all be consistent and mutually reinforcing, if the motion picture is to influence motivation, attitudes, and opinions.

MEDIA RELATIONSHIPS TO LEARNING TASKS

by Mark A. May

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Acquisition Responses Are Specified by the Learning Task

All A-V presentations require close and sustained attention. Beyond this first stage, the particular responses made to the audio-visual stimuli are specified by the learning task. The cues on which attention is focused must be relevant to the learning task. The meanings attached to the relevant cues are also, in some respects, determined by the learning task.

If the task is to reproduce the materials verbatim from memory, the responses required to perform it are different from those that would be required to produce evidence that the substance of the material had been comprehended. If the task is to perform a sequence of acts, such as knot tying or assembling the parts of an automobile ignition distributor, the responses required by the demonstration are also different from those required by verbal learning tasks.

Before any useful statement can be made about the roles of visuals and verbals in motivating, cueing and reinforcing acquisition responses it is necessary to know what kinds of responses are being considered and the conditions on which they depend. For example, if the task is to acquire a perceptual-motor skill, or to memorize a list of names or verses of poetry, or to form a new concept, a number of repetitions or amounts of practice may be required. But if the task is to understand an explanation, or to grasp a principle, a single presentation may be sufficient. As to the relative roles of words and pictures, it is rather obvious that a motion picture of a performance is much more helpful for cueing the correct manual responses than a verbal description of the performance or a set of verbal instructions. The relative values of words and pictures in teaching the binomial theorem or the second law of thermodynamics might be quite different.

Excerpted from Word-Picture Relationships in Audio-Visual Presentations (A Working Paper). Prepared under U.S. Department of Health, Education, and Welfare, Office of Education, Contract No. OE-5-16-006. July 20, 1965.

A Suggested Taxonomy of Learning Tasks

In order to proceed, there is need for a taxonomy of learning tasks, based on and related to a taxonomy of educational objectives, and articulated with the characteristics of audio-visual materials. One source of materials for such a taxonomy is the large number of evaluative studies that have been made in which A-V presentations have been compared with conventional methods of teaching. This has been done for practically every subject in the curriculum from the first grade through graduate and professional schools. The list of such studies is long.

* * *

Without the benefit of information that might be derived from such a study, a crude analysis of learning tasks is presented here. It is not claimed to be exhaustive. Its purpose is to serve as a kind of map for guidance through a considerable amount of unexplored territory. The two main divisions into reproductive and productive tasks were suggested by Gagné (7).

1. Reproductive Tasks. Included in this category are all tasks in which the learner is required to reproduce or to recognize a reproduction of, the whole or a part, of the materials learned. Some are:

a. Verbal reproductions--illustrated by experiments on memorizing. Included here are such tasks as memorizing and reproducing lists of words, verses of poetry, paragraphs of prose. Also are included tasks of learning the vocabulary of a foreign language.

b. Manual reproductions. Included here are most of the tasks involved in the acquisition of perceptual motor skills.

c. Pictorial reproductions. Included here are tasks of reproducing the materials learned by drawing and copying from a model.

2. Productive-Constructive Tasks. In this category are all the tasks that require evidence that the substance of the material was comprehended, and can be utilized in other situations. Examples are:

a. The task of recognizing an item of information or an idea when it is stated in terms different from those used in the learning situation.

b. The task of writing, in the student's own words, the substance of materials learned, as in the typical essay-type of examination.

c. The task of reproducing an explanation in the students own words.

d. The task of giving examples of a concept.

e. The task of solving problems similar to those given in the presentation.

f. The task of translating a foreign language.

Processes and Products of Learning

It will be noted that this classification is based on the products rather than the processes of learning. When we speak of learning by classical conditioning, operant conditioning, discrimination, assessing probabilities of reinforcement, memorizing, insight and problem solving, we are speaking of the processes, not the products of learning. At this point the problem arises as to how to match processes to products. Which of the various types of learning are required by, or best suited for, the achievement of types of learning tasks? In a recent volume edited by Melton (19) seven distinct categories of learning are recognized and discussed by fourteen authors. Gagné (8) has identified eight types of learning arranged in a hierarchial order. There is a considerable amount of overlap between Melton's seven categories and Gagné's eight types. All of them have been shaped out of laboratory experiments on animal and human learning.

Learning from an A-V presentation appears to involve a mixture of these types. The problem is to discover which of the various types best fulfill the conditions on which the achievement of different kinds of learning tasks depends. Such a discovery would greatly simplify the task of assessing the relative merits of words and pictures for motivating, cueing and reinforcing the response required by different tasks. It would also enable us to apply to classroom learning many of the facts and principles derived from experiments on laboratory learning.

In the discussion of acquisition responses that follows, an effort will be made to relate them to the type of learning that seems most appropriate to each type of task.

Responses Required by Reproductive Tasks

Consideration will be given first to responses required by reproductive tasks, which include verbal, pictorial, and manual reproductions of the learned materials.

The Role of Words and Pictures in the Learning of Verbal Associations

An illustration of this type of task is learning the vocabulary of a foreign language by the method of paired-associate. Pioneering research was done on the problem of Lumsdaine (16) and by Kopstein and Roshal (15), Kale and Grosslight (13), Bern (2), and Asher (1). These studies are summarized by Hartman (11).

Lumsdaine (16) prepared a large number of pairs of unrelated words, pairs of unrelated pictures, pairs of picture and words, and pairs of words and pictures. The pairs were presented in random order, 16 pairs to each list, to intermediate grade school children and to college students. The experimental conditions were varied in respect to rate of presentation and in other respects.

The members of each pair were selected to minimize previously learned associations. The learning task was mainly that of rote memorizing. It was found that under all conditions and for different grade levels of students, picture-word pairs were learned best, word-picture pairs least, with word-word and picture-picture in between.

The importance of this experiment lies in the theoretical reasons why pictures are better stimulus terms than words. One reason is based on the principle of temporal contiguity. While looking at a picture a can simultaneously say a word out loud or silently, but while looking at a word it is difficult to say another word at the same instant of time. Furthermore it is impossible to say two words at the same time. The response word to a picture can be practiced while looking at the picture, but to practice saying a name of a picture while looking at a word is much more difficult.

Words are poorer stimulus terms than pictures mainly because they are apt to have more than one meaning. The word "fence" for example, may mean a barrier, or a dealer in stolen goods. But the picture of a barrier is perceived as a fence and not as a dealer in stolen goods. Words are better response terms than pictures partly because most people have had a great deal more experience in seeing an object or picture, before hearing or seeing its name, than vice versa. Furthermore, in Lumsdaine's experiment the criterion task was always to name the response term when the stimulus term was presented. When a picture was presented it was necessary to recall the word associated with it, but when a word was presented the subjects were required to name the picture that had been associated with it.

In this connection it is noted that when Bern (1958) changed the criterion task from recall to discrimination, presenting both words and pictures in the test situation, he found that for the performance of this task, picture-picture and word-picture were superior to word-word and to picture-word. This it would appear that when the criterion task is changed the associations that mediate the correct responses are different.

The role of mediators in paired-associate learning was investigated in an experiment by Davidson (5). The materials were pairs of pictures of objects familiar to second grade school children who served as subjects. They were divided into a high and low ability group based on the results of a preliminary experiment, in which they were tested for initial abilities to form associations between pairs of pictures. Each of the two groups was assigned at random to five experimental conditions. For each condition twenty pairs of pictures were exposed at the rate of a pair every five seconds. There followed two test trials during which only the stimulus picture was exposed and the task was to choose from four pictures in a work book the one that belonged to the stimulus picture. On the second trial the order of presentation was changed.

For condition A no mediators were employed. For condition B the experimenter pronounced the names of the two pictures (e.g., "chair"--"shoe") on the presentation trials, but not on the test trials. Condition C was the same except the experimenter inserted a preposition between the pairs (e.g., "chair under shoe"). For condition D a mediating sentence was used such as "the chair doesn't look large under a big shoe." For condition E the picture showed a big shoe on a chair.

The mean scores (maximum 40) took a big jump beginning with condition C where connective mediators were introduced; for the high ability groups the jump was from a mean of about 13 to 33, and for the low ability groups it was from about 10 to 26. At the level of conditions D and E where sentences and pictures were the mediators the low ability groups had combined mean score almost as high as the combined means of the high ability groups. When pictures of relations (such as a big shoe on a chair) were added to sentences the combined mean score of both groups went up about five points.

Thus it would appear that when powerful mediators are introduced children of both high and low associational abilities can achieve almost perfect scores on two trials. Pictorial mediators added more scores to sentences, than sentences added to prepositions, and both added substantially more to the pronunciations of the names of the two pictures.

The role of words and pictures in paired-associate verbal learning has been further investigated by studies of learning the vocabulary of a foreign language which has an origin different from English. Two studies on the learning of Russian vocabulary have been reported. First Kopstein and Roshal (15) found that picture-word combinations were superior to word-picture confirming Lumsdaine's results. The second was by Kale and Grosslight (13) who translated Russian nouns and verbs from the Cyrillic alphabet to English equivalents and presented paired lists in five versions of a film. In one version, pairs of words were presented with English words always in the stimulus position. In the second and third versions, English-Russian nouns were presented below a picture of the object denoted by each noun. Each pair of verbs was shown below a motion picture depicting the action denoted by the pair. The fourth version was the same except that the printed words were pronounced by the narrator. In the fifth version, the students repeated the pronunciations after the narrator.

Ten films were used, five for verbs and five for nouns. Each version contained twenty pairs. The procedure was to present the pairs in each list at a rate of 5 to 11 seconds each. After a preliminary presentation of each list, six test trials were run in which each English word was exposed briefly and the subjects required to write its Russian equivalent on a workform while blank film was exposed for 10 seconds, after which the correct word was flashed on the screen. The criterion was the number of Russian words spelled correctly or nearly so on each trial.

The main variables in the presentations were (a) words alone, (b) words with pictures, (c) words with pictures plus pronunciation, (d) audience vocalization of the words, (e) fixed *vs.* random order of pairs, (f) pictures and Russian words alone *vs.* pictures of English-Russian pairs. Under all of these conditions the presentations *with* pictures, both motion for verbs and stills for nouns, were more effective than presentations without pictures. Pictures shown in combinations with pairs were somewhat more effective than pictures with Russian words alone.

This result would seem to indicate that on the test trials where the English word was the stimulus and the task was to write the Russian equivalent the picture functioned to mediate the correct response. The order of associations could have been:

$$\begin{tikzcd}\text{English word} \arrow[r, dash, dashed, "(1)"] \arrow[rr, bend right, dashed, "(3)"'] & \text{Picture} \arrow[r, dash, dashed, "(2)"] & \text{Russian word.}\end{tikzcd}$$

It was easier to learn association (2) than association (3) provided association (1) had previously been learned. In terms of classical conditioning the picture functioned as the unconditioned stimulus which reinforced the power of the conditioned stimulus (the English word) to elicit the conditioned response (the Russian word).

The pronunciation of the pairs of words by the narrator tended to interfere with learning. In all comparisons of pronunciation *vs.* no pronunciation on tests of immediate recall, the mean learning scores were less when the pairs were pronounced. But this was not the case on tests of delayed recall. The authors conjectured that one of the reasons for the interference was that a transliterated Russian word is not necessarily pronounced according to the English rules of phonetics. In writing a Russian word in the English alphabet the subjects were perhaps guided by how it would sound in English.

The conditions of the foregoing experiments on the relations between words and pictures in rote verbal learning of paired-associate are different from those involved in associative learning from A-V presentations in two fundamental respects. First, associative learning from A-V material is more meaningful; second the words are usually presented orally instead of visually. Further experiments are needed in which the pairs are more meaningfully related, and presented orally.

The interrelationships between aural and visual presentations have been investigated by Asher (1) in a series of three experiments on learning Spanish vocabulary. One group of college students learned lists of Spanish words visually and, after 48 hours, relearned the same list aurally; another group learned the same list aurally and relearned them visually. There were ten lists of about 10 words in each list. After all lists had been learned and relearned, all subjects were given a story to translate that contained the words in all of the lists.

In the first experiment, each English word was printed on a card with two Spanish words. Each subject was required to choose the correct one. The subjects who were learning visually were shown the three words and required to write the correct choice; the aural subjects heard the three words pronounced and were required to pronounce the correct one. Immediately after each response the subject was told whether it was right or wrong. After two correct responses the card was dropped from the list. The score for each list was the number of initial and perserveration errors. This same procedure was used in the relearning sessions.

In the second experiment, pairs of pictures and their Spanish names were presented at intervals of one second per pair for each list of ten pairs. On the test trials, only the pictures were presented and the subjects required to write or pronounce the correct Spanish word. The third experiment was the same except that English words were used instead of pictures.

Forty subjects participated in each of the experiments. Twenty learned aurally and relearned visually; and 20 learned visually and relearned aurally. All subjects were unfamiliar with the Spanish language.

All subjects were pretested for sensory dominance and for guessing ability. Sensory dominance was measured by requiring all subjects to learn an initial list visually, and another list aurally. Students who made the fewest errors on the first list were considered visually dominant; those who made the fewest on the second list were considered aurally dominant. Students who guessed the correct answer on the first presentation of a pair the most times on each list were considered to be the best guessers. Guessing ability was found to be highly correlated with all other measures of learning.

Under all conditions the students who learned visually and relearned aurally made fewer errors in learning than those who learned aurally and relearned visually. Among those who learned visually, the visually dominants learned somewhat better than the aurally dominants; and of those who learned aurally and relearned visually the aurals made fewer learning errors than the visually dominants. The correlations between guessing scores and learning and relearning scores were significantly positive; but significantly negative with scores on retention tests. Furthermore, the retention test scores of those who learned visually were not significantly better than for those who learned aurally.

This final result indicates an interesting relation between learning and retention. It supports the hypotheses that, regardless of the channel through which verbal materials are learned, retention is mediated by the sensory dominant channel. Visually dominant subjects recall materials learned aurally in terms of how they would look; and aurally dominant subjects recall visually learned materials in terms of how they would sound when pronounced. If this hypothesis is correct, it is of extreme importance for assessing the roles of visual and auditory stimuli in A-V presentations.

The Role of Visuals and Verbals in Learning to Perform Skilled Acts

Two different kinds of learning tasks are immediately recognized. First are tasks performed with one's hands such as handwriting, drawing from a model, tying knots, assembling the parts of an instrument, playing golf, tennis, and so on. The second are tasks performed with one's speech apparatus, as illustrated by learning to pronounce words correctly, to speak fluently a foreign language, to sing, to whistle, and so on. In between are tasks that involve both the hands and the lips such as learning to play a musical wind instrument.

It is obvious that in learning to perform manual tasks visual or audio-visual presentation should be more effective than merely being told how to do it, or given printed instructions in how to perform it, as every American father on Christmas morning knows all too well. It is equally obvious that in learning vocal skills, auditory demonstrations are more effective than visual ones. It is true that deaf children can learn lip reading, and blind children can learn manual performances. But such learnings are very difficult and require a large amount of practice and patient teaching.

Most of the experiments on the roles of visuals and verbals in learning from demonstrations are found in studies on perceptual-motor learning, in studies of speech, and learning to speak a foreign language. Such experiments, unfortunately, were not designed to test the relative merits of words and pictures for performing the functions that are required by these learning tasks. Needed are some experiments designed to test hypotheses such as the following:

1. The hypothesis that visual demonstrations are more effective than verbal descriptions for defining the learning task, not only in respect to the end result, but also in relation to the steps required to achieve it. It is further hypothesized that a visual-demonstration of the performance plus a verbal description of the steps would be even more effective.

2. Experiments performed thus far demonstrate that the function of cue identification by pointers, circles and labels is more effective than verbal directions alone. Would combinations of visual-verbal be even more effective?

3. The hypothesis that visuals in motion are more effective for the formulation of a "perceptual blueprint" (Sheffield, 21) from which the correct sequence of response in performing a skilled act can be read off than a verbal description of the sequence of movements. This hypothesis should be checked against May's theory (see below) that verbals often do play a significant role in learning from a demonstration.

4. The hypothesis advanced by Gropper (10) that seeing oneself perform a task correctly is more reinforcing than merely being told that it is correct on the ground that "seeing is believing" should be checked by further experimentation.

May's argument (17) is that covert verbal responses to a demonstration as it is being viewed perform a function similar to that of Sheffield's visual "perceptual blueprints." If during a demonstration the viewer tells himself what responses are made at each step, or repeats to himself what the narrator tells him, this sequence of verbal responses will become conditioned to the sequence of visual stimuli, which in the test situation are similar to those in the learning situation, and hence will serve to cue the correct sequence of responses. As the performance becomes more practiced these verbal mediators will tend to drop out, and thereafter the cues that control the correct sequence of responses will be largely visual and proprioceptive. Eventually the visuals may drop out and the learner can perform the act with his eyes shut.

The model for this theory of learning from a demonstration is that of delayed imitation, described at length by Dollard and Miller (6). A driver finding his way through a maze of city streets by following a leader car, is a case of immediate imitation. But finding one's way later without the benefit of a leader depends on how many cues were noted and recalled as to where to make right and left turns. In this case the performance is guided by verbal recall of the cues. So in learning from a demonstration film, if the learner can verbalize self-directions for each step, and remember them in the test situation, he can successfully perform the task, provided these self-induced verbal directions have already acquired the power to elicit the correct responses. The verbal responses are elicited by the similarities between sequences of visual stimuli in the learning and in the test situations.

This section on associative responding may be concluded by noting that the formation of associations between stimuli and responses usually requires some sort of a mediating link. (See Gagné, 8, p. 99). As noted above, the association between visual stimuli presented by the steps in a demonstration and the responses required for its performance may be mediated effectively by words. The association between English words and the Russian equivalents may be mediated by pictures or by some other kind of linkage. Thus, for some learning tasks, words serve the function of mediators better than pictures; for other tasks, pictures or visual images are more effective than words. Psychological studies of the mechanisms involved in associative learning indicate that visual images are often used to link pairs of words (see Cofer, 4). For example, the pair of words "bow-trousers" is apt to elicit a visual image of trousers on a bow-legged man; "spoon-mailbox" elicits an image of a spoon lying in a mailbox. Other linkages may be provided by a knowledge of the derivation of words, such as terra-earth (mediated by terrestrial) (from Gagné, 8, p. 101).

The more meaningful the terms to be associated, the easier it is to find linkages. The terms "terra" and "earth" have almost the same meaning. In contrast the syllables "Zok-bif" require much more inventiveness to construct a connecting link.[1] This illustrates the importance of perceptual learning as a prerequisite to associative learning.

A pair of associates may be regarded as a chain of three links. Learning lists of words or verses of poetry constitutes a chain of many links. Learning that Mt. McKinley in Alaska is 20,300 feet high, making it the highest mountain in the United States, is an example of verbal chaining that is characteristic of factual information learning. The conditions on which such verbal learning depend are discussed by Gagné (8, p. 103-112). One of the conditions is that the meaning of each link in the chain must have been previously learned and discriminated from other links, and that the mediators between links must have been previously learned. Most of this previous learning is designated in this paper as perceptual learning.

Responses Required by Constructive Tasks

At this point we turn from the reproductive types of learning tasks to productive-constructive types. Many A-V presentations require more than perceptual and associative learning. The tasks are grasping an idea, understanding an explanation, comprehending a general principle, and solving a problem. Learning to perform these tasks from one or two presentations requires a considerable amount of previously acquired relevant knowledge which can be recalled and applied to the tasks. Lumsdaine (16) found that the amount of the gap between previously acquired knowledge about the phenomena of osmosis, as measured by a pretest, and a perfect score on the posttest filled by one presentation was considerably greater for students with the higher pretest scores than those with the lower scores. The more a subject already knew about the topic, the greater was the percentage of new knowledge gained from the film.

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[1] Bugelski (3) found that some subjects connected a pair of nonsense syllables, dup-tez, by translating it into "deputize."

The question now arises as to what kinds of previously acquired knowledge are needed to understand an explanation or to grasp a new idea, or to comprehend the substance of a presentation. First of all, the student must be able to perceive correctly the new meanings of the words and sentences in the narration and in the visuals. To the extent that these meanings have not been acquired, an amount of perceptual learning will be required. Second, the learner should have acquired associations between objects, places, events and relationships. Mediational linkages between stimulus and response terms, or units, must have been acquired and retained. Third, previous conceptual learning may be very useful. Knowing the names of the classes or categories to which the verbals and visuals belong, and knowing what the cues connote, as well as what they denote, should be helpful. To the extent that the necessary concepts have not been formed, conceptual learning will become part of the new learning task.

These prerequisites to substance, or idea learning, may be viewed as types of prelearned instrumental responses that lead to the goal responses of correctly and fully comprehending the materials in the presentation. The better these instrumental responses have been learned, the easier it is for the learner to march straight ahead to the goal without hesitating, hemming-and-hawing, and trial and error. If these instrumental responses have not been learned, or learned but not applied, then a considerable part of the instruction in an A-V presentation is precisely that of telling, illustrating, and demonstrating, the correct instrumental responses (see Gagné, 7).

Assuming that students have already acquired these prerequisite kinds of knowledge, then what kinds of further responses must be made to the material in order to perform the criterion task successfully? What, for example, is required by a comprehension reading test beyond a knowledge of vocabulary and sentence structure? What responses must a student make to a paragraph in order to answer correctly the test questions about the idea or ideas that it conveys? What responses must a student make to an A-V presentation in order to "get" the new information that it conveys, or to comprehend its full meaning?

Many instructional films teach both facts and explanations. Students may learn the facts but fail to grasp the explanations. This point is illustrated in a study by May and Lumsdaine (18). They noted that students who had had previous instruction on the phenomena of osmosis made much greater gains on questions of facts about temporary osmosis than on questions about the explanations of these facts. But for explanations about permanent osmosis the results were reversed. This difference was traced to the fact that the animated diagrams illustrating the passage of molecules of different sizes through semipermeable membranes were much clearer and more easily comprehended for the phenomena of permanent than for temporary osmosis (see p. 157). This illustrates the importance of animation that clearly depicts an explanation. The correct responses to questions about explanations were perhaps mediated by the retention of visual images of the animation. They aided the students in grasping the explantion.

The role of words and pictures in the construction of new concepts. For the purposes of this paper a concept is any class or category of objects, events, relations or stimulus elements, that share one or more common properties, and which can be identified by a lebel or a definition. Most concepts are abstract because their identifying properties are abstracted from concrete percepts. The concepts of length, volume, velocity, position, tallness, squareness, nouns, verbs, etc. do not refer to any particular object or word. They are labels for definable categories.

From the standpoint of behavior, the label or definition of a class of objects, or relationships, can elicit a response of naming a member, or giving an example. Conversely, an example in the stimulus position can elicit the name of a label or a definition. Concepts are, therefore, of great importance for classifying and organizing knowledge so that it is retained and can be used. The fact that they are associations which function both as cues and responses is of signal importance (Kendler, 14) (see also Goss on the "Acquisition of Perceptual Schemes," 9).

New concepts may be formed either by discovery or by instruction, or both. In laboratory experiments, the learning task is that of discovering the features or properties which arrays of stimulus patterns have in common. A strategy often employed by experimental subjects is to make guesses or form hypotheses about possible key features, from the initial presentation, and test them by observations of other examples. This is quite similar to the trial and check phase in perceptual learning. If the key cue is only one feature, such as size or shape or color, learning is fairly rapid; but if it is a particular size plus a particular color, in a particular position, learning is much more difficult. But once the key feature, or combination of features, is discovered a rule is formulated which controls the correct response to further examples.

Such rules can be taught without requiring the learner to go through the long and tedious process of discovery.[2] The rule can be communicated in the form of an operation definition. The students are simply told that if a pattern contains an element that is square and red it belongs to a class. If the class can be named by a common noun or nouns, such as "red squares" these words will then control the correct response to subsequent examples. But as Gagné (8) has pointed out, the new concept is composed of two previously acquired concepts of redness and squareness.

A-V presentations usually attempt to teach new concepts by definition and examples. The success of this procedure depends on a number of factors such as the choice of words by which the concept is defined, and the amounts of previous perceptual and associative learning that is relevant to the task of comprehending the full meaning of the concept. Take for example a concept that may be new to some students--that of citrus fruit. This concept may be introduced simply by stating that citrus fruits are oranges, lemons, limes, grapefruit, tangerines, and others.

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[2] Homme and Glaser (12) developed a system for writing frames for a program of instruction in terms of rules and examples. It is called a ruleg system.

It is assumed that percepts of oranges, lemons and other examples have previously been formed. Differences between them can easily be perceived. But in what respect or respects are they alike? Why are they called citrus fruits? One common property is that they all contain relatively large amounts of citric acid. But what is citric acid? It is defined chemically as C_6, H_7, O_8. But this definition is nonsense to students who have not studied chemistry. The point is that until the concept citric acid has been clearly formed the words "citric acid" means only a kind of an acid that is found in one class of fruit. This example illustrates the point that the most distinguishing feature is not easily perceptible unless one's taste has been educated to the level of being able to identify a citrus fruit by tasting it. This being the case, the concept remains in a state of partial formation. From a practical standpoint this is no great disadvantage. The class of citrus fruits is relatively small. The concept can be acceptably formed by naming its members. Any fruit that is not on this list is known not to be of the citrus variety.

When the instances, or cases, are so numerous that they cannot all be named and classified into exhaustive lists, the learning task becomes one of being able (a) to define verbally the distinguishing features of a class, (b) to give examples of it, and (c) to recognize examples that do not belong to it. Most children think they know what a hotel is and can name a few examples. But do they know what it is about such a building that distinguishes it from other buildings of similar appearance? The answer is, of course, the kind of uses made of it. But similar uses are also made of homes and apartment buildings. The verbal formulation of what it is that distinguishes hotels from all other classes of buildings by giving examples that fulfill and do not fulfill, these specifications are the major tasks of conceptual learning. This learning consists of bringing the response of giving correct examples under the control of the name or a verbal definition.

Very little is known about the relations of visual and auditory stimuli in concept formation. The stimulus materials used in laboratory experiments are mostly visual. Stimuli that activate any sensory reception are classified and labeled. The labels are always verbal. The members of the categories are for the most part percepts. Concepts are constructed from percepts. If the task is to give an example of a concept, the stimulus is the name or the definition, and the response is verbal. But if the task is name the class to which an object belongs, the stimuli may be either the object, a picture of it, or its name.

Olson (20) compared the effectiveness of pictures, letters and numbers for the attainment of concepts by high school sophomores. The stimuli were presented on cards by adding one at a time. Each time one was added the subjects were required to identify and record the common element. If the correct element was identified on the appearance of the second stimulus the score was 10 points. It decreased as more stimuli were required to identify the common factor.

Two sets of pictures were used. One set was pictures of parts of a reciprocating machine, the other was pictures of levers. The letters were in groups of five with three in alphabetical order; and the numbers were in multiples of three.

For one group of subjects the order of presentation was from obvious to subtile (i.e., easy to hard), for another group the order was random; and for a third group it was from hardest to easiest. The results show that the order of presentation was much more important for the picture problems than for either the letter or number problems. This could be due to the fact that the number of problems were intrinsically easier than the picture problems. For the picture problems of reciprocating action the mean score of the "easy to hard" group was 7.8, for the "random" group 3.3, and for the "hard to easy" group 2.3.

It is difficult to evaluate the results of this experiment without seeing the dissertation on which the article reporting it was based. The author does report, however, that the selection of "obvious" and "subtile" examples of the pictorial concepts was based on rating by an independent sample of high school students, while instances of the letter and number concepts were selected by the experimenter.

The role of words and pictures in the acquisitions of responses of prehending and comprehending. Here, the learning task is that of grasping a new idea, understanding an explanation, or comprehending the full meaning of a presentation. The notion of getting something from reading a book, hearing a lecture, or seeing a film, runs throughout educational literature. Students often complain about a presentation being over their heads, or failure to get anything new from it. To seize, grasp or latch onto is to prehend; to grasp all there is to be grasped is to comprehend.

What, now does one do to prehend and to comprehend? What kinds of responses are required, and how are they learned? Let us begin with the physical acts grasping and see if we can build up to higher mental processes. A monkey prehends the limb of a tree by wrapping its tail around it; and an infant prehends a pellet with its thumb and forefinger; adults pick up and manipulate objects with their fingers or by the use of instruments. But with what bodily organ do they "pick up" ideas? The obvious answer is, with their brains.

There are no doubt lines of connection between physical and mental prehension. There is a great deal of evidence, derived both from child psychology and the history of education, which clearly indicates lines of connection between object manipulation in early childhood and later manipulations of their surrogates. These lines of development are difficult to trace. There is involved, no doubt, a hierarchy of acquired abilities, beginning with the unlearned abilities of infants to manipulate objects. The line of development might stem from proprioceptive and autonomic stimuli produced by physical acts of prehending.

When a physical object is grasped, it may be reported as feeling hard or soft, large or small, round or oval or square, rough or smooth, pleasant or painful. Such verbal reports stem from feedbacks into the central nervous system of tactile, proprioceptive, and autonomic stimuli. These feedbacks provide several items of information--such as, the object is something that is round, hard, and smooth. It is the combination and integration of these items of information that constitute an "idea" of the object. The idea is comprehended when all relevant information is in and integrated.

The question now arises as to how one can grasp an idea of something without the benefit of first-hand information obtained from physical grasping and manipulation. The obvious answer is, it is done by grasping the meanings of the symbols and pictures that represent or stand for the idea. But what kinds of covert responses to surrogates correspond to the physical ones of grasping and manipulating? A good guess is that they are faint replicas of the physical responses. Replicas are muscular tensions, and other implicit responses, which produce autonomic and proprioceptive stimuli similar to those produced by physical manipulation. These covert replicas may be elicited by visual and verbal stimuli which by past experiences have become conditioned to them. By primary stimulus generalization, pictures of objects will elicit the same implicit muscular responses as seeing an actual object when it is out of reach. By the process of higher order conditioning, names of objects, verbal descriptions, and diagrams can gain control over the implicit responses of grasping. Thus, the implicit muscular responses and neural reactions could be the instruments by which ideas and explanations are grasped and understood.

A connection between responses required for the "mental" grasping of ideas and those involved in the acquisition of first-hand knowledge by manipulating and observing the physical environment, is an instance of a more general proposition. The proposition is that all vicarious learning--*i.e.*, by being told or shown, stems from, and is based on, responses by which knowledge is acquired by first-hand experiences. These primary experiences are observations and manipulations. A great deal about the environment is learned by looking, listening, touching, tasting, sniffing and noting changes as they are sensed. The sensing of environmental stimuli is basic to perceptual learning which, in turn, is basic to learning by observations, which is further basic to all observational sciences such as astronomy.

This is not all. Humans can learn by observing the surrogates, or representatives, of the environment. An object, place, or event can be represented by a picture, or described in words. Such surrogates acquire meaning by the process of perceptual learning. It is only after such meanings have been acquired, is it possible to learn by observing surrogates. The more firsthand knowledge a child has acquired about various features of his environment, the easier it is for him to acquire new knowledge from A-V presentations, provided he has also learned the relation between visual and verbal representatives and the feature of the environment for which they stand.

Valuable firsthand information is also gained by manipulating objects in the environment and noting what happens. This is illustrated by operant conditioning, and other forms of learning by experience. Experience is defined by John Dewey as "doing and undergoing"--acting on the environment and taking the consequences. This may be mere doing for its own sake, as illustrated by the play of children. It may be the kind of doings that are characteristic of all experimental science.

When objects, places, events and relations are represented by symbols, either linguistic or mathematical, such symbols can be manipulated independently of the objects or concepts that they represent. Some symbols denote objects and relations, other connote features abstracted from the environmental objects, events and relationships. This makes it possible to acquire a great deal of new knowledge without undergoing firsthand experiences.

This view of the learning process puts us in a better position to assess the relative merits of words and pictures in understanding explanations and in comprehending abstract relations and concepts. Most of the responses here involved are, as previously indicated, the covert ones of prehending and comprehending. The question is what are the relative merits of words and pictures in motivating, cueing and reinforcing these responses.

The properties of words and pictures are discussed earlier in this paper and need not be repeated here. The problem is how to utilize them for the achievement of different tasks. The rules are different depending on the functions that words and pictures are intended to serve.

The construction of visuals that will aid students in prehending and comprehending principles and abstract ideas presents problems of finding visual representations with which students are familiar. Visual representations are more likely to elicit correct responses than verbal descriptions. Bar graphs are useful for visualizing relations between quantities of statistical data provided the student understands that the higher the bar the greater the amount. Visualization of principles and abstract relations that do not elicit the desired responses may elicit wrong responses, or leave the student in a state of confusion. For example, May and Lumsdaine (18) found that an animated diagram of the movements of salt and water molecules through a semipermeable membrane failed to elicit the prehension of the point that the key to the explanation is the relative size of molecules in relation to the pores in the membrane. A general rule might be that the effectiveness of a visualization of an explanation, or of an abstract principle, depends mainly on the extent to which it contains a pattern of stimuli that will evoke the desired response.

A recent study by VanderMeer and Thorne (22), on the use of filmstrips for teaching the relations between The Sun and Its Planets, illustrates the problem of finding an optimum combination of words and pictures for teaching astronomical facts and principles. The visuals were mainly photographs or drawings of the sun and the orbits of its planets. The verbals were printed captions. The subjects were students in grades 5 to 12. Knowledge of the contents of the filmstrip was tested with a large number of multiple choice items.

This filmstrip went through three revisions. Each was based on the test items that were incorrect on the preceding version. The effectiveness of each revision was tested by assigning groups at random to the originals or to the first revision and to the second revision. Items correct on the revised version were compared with those incorrect on the original. Also mean total scores were compared.

The revisions of the graphic and pictorial elements that seemed to improve learning rather consistently were (a) increasing the "iconicity" of a frame showing how the waxing moon would actually look from the earth rather than from other positions, (b) the multiplication of similar cues without increasing the content to be learned; (c) the additions of cue identifiers such as directional arrows. Other revisions which improved on some but not all parts, and which were better in some, but not all grade levels, were labels of objects, and grouping objects in ways to facilitate an estimate of their numbers. Plane views instead of perspective, and boundary lines around significant cues were also improvements.

Verbal captions were improved by underlining or capitalizing key words. The uses of repetition and redundancy for unfamiliar audiovisual materials tended to facilitate learning.

This study illustrates the difficulty of finding combinations of verbal and nonverbal stimuli that will gain control over all criterion response for all students. Another interesting point is that the greater the "iconicity," or realism of a visual, the greater is the probability that it will elicit a correct response. This is attributed to previous learning. Gropper (10) reports an experiment in which a ball and ring were used to illustrate the principle that matter expands when heated. A cold metal ball is inserted in a ring and then heated. When heated the demonstrator could not pull it out of the ring. This visual demonstration of a principle was probably worth a good many words.

The relative merits of visuals and verbals for giving examples of abstract ideas and principles have also been investigated. In some instances a general principle may be understood from a simple statement.

In the case of Gropper's (10) experiment, the simple statement that "all metals will expand when heated" may be sufficient provided the concepts of "metals," "expand" and "heat" have been previously formed. A more general principle that "all forms of matter expand when heated" may require examples showing how metals, wood, water and gases obey this law. At this point visual demonstrations of examples may aid in comprehending the full meaning of this principle. As Gropper (10) points out it is not always possible to see what is happening when matter expands, but it is possible to see the effects, as in the ball and ring experiment. If the purpose is to go further and explain why matter expands when heated, visualization by animation showing the increases in speed of molecular action may be employed.

There are still other ways in which examples of abstract principles can be visualized. One is, as Gropper suggests, by analogy. Elective-motive forces are analogous to hydraulic systems. The activities of electrons, protons, and other "trons" in various kinds of atoms may be represented by mock-ups.

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